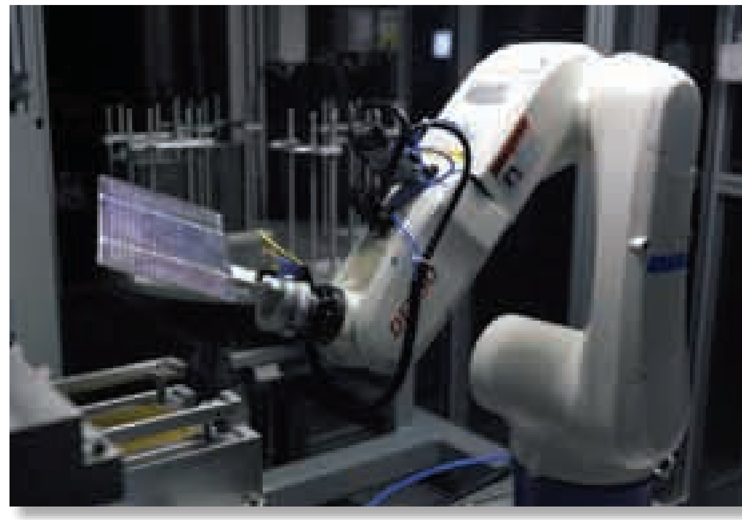
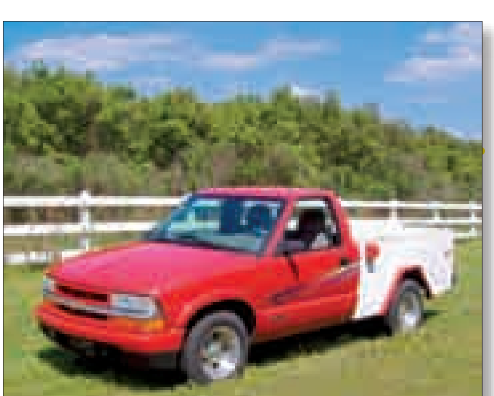
REC Solar

DELIVERING ON THE PROMISE OF SOLAR ENERGY

contents

October & November 2008



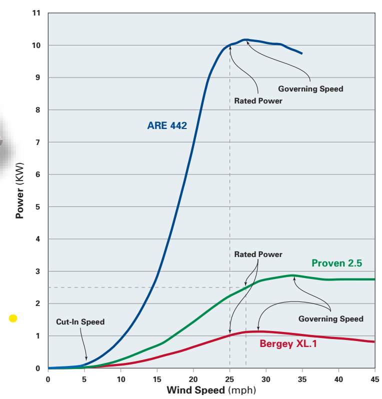


Clockwise from lower left: Mark Hazen, Shawn Schreiner, www.sunearthinc.com, www.nrel.gov, www.nrel.gov, www.trojan-battery.com

On the Cover

Solar electricity or solar hot water? These lucky homeowners chose both. But if you have to choose just one, see the article on page 40 first.

Photo by Shawn Schreiner



Regulars

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from us to you

RETURN & VALUE

I frequently hear people complaining about the high cost of solar-electric (PV) systems. One reader recently complained, "18 years to break even." Breaking even sounds good to me. This is a better return than almost everything else we spend money on. Only financial instruments and real estate may do better, as far as I can see. All other purchases we make are a continual loss.

It's strange that the purchase of clean energy systems is often viewed purely as a financial investment when almost none of our other purchases are defined that way. With most of our investments and everyday purchases, we typically decide what we want, need, value, and enjoy.

I wonder why we expect more out of renewable energy systems than we expect out of our cars, furniture, clothing, entertainment, and vacations. None of these things have any financial payback, and yet they are valuable to us. If you asked a car salesperson what the payback on a new truck is, they might say, "Huh? You want transportation, right?" With renewable energy systems, the corresponding answer is, "You want clean energy, right?"

Any talk about "breaking even" essentially pits solar energy against a system of aggressively subsidized dirty energy. Suppose the government subsidized poisoned milk, and let dairy farmers dump their manure into streams, fouling the environment while selling the bad milk at $3 a gallon. Your neighbor's whole, organic milk, selling for $7 a gallon, might seem really "expensive." But once you factor in all the costs and effects on your health, the environment, and your community, your neighbor's milk seems like a much better deal. The true value of renewable energy (RE) cannot be measured by dollars alone.

In a perfect world, the choice to use RE should be based solely on our values—not financial payoff or upfront costs. Even if we consider only cash, we need to look at RE systems in a different way—for the long term. When you invest in a PV system, you're buying 40 to 50 years of electricity at a fixed cost. This lump sum seems expensive, since we rarely pay for anything else decades in advance. But what if your car salesperson offered you a car that would generate no emissions, last 40 years, not require buying gasoline, and run like a dream the whole time? Once you got over your initial doubts, you'd realize that if it was for real, it would undoubtedly be *very* expensive. But to people who value quality, durability, predictability, and reliability (and don't care about being "in style"), it would be a great buy.

Solar energy systems are a similarly great buy, if designed and installed well. Only when you take the long view—and focus on the full importance—will you see the true value of solar investments.

—Ian Woofenden for the *Home Power* crew

Think About It...

"It is the greatest of all mistakes to do nothing because you can only do a little."

—Sydney Smith (1771-1845)

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Lightning Protection

I have two wind turbine installations (ARE 110s) and need to do something about lightning protection. Our turbines have never been struck (and I know it's dangerous just writing that), and the tower is set in clay soil and appears to be adequately grounded. I have ARE's lightning protection recommendations, but the equipment they recommend seems expensive. Do you have guidelines and cost estimates for protecting a tower and turbine from lightning?

Paul Kenyon • Bridport, Vermont

Courtesy www.mattemrichphoto.com

First, I need to state that I am with ARE, and we offer the expensive system that you refer to. Grounding systems first reduce the attractiveness of the tower to lightning, by reducing the charge buildup in the tower. Second, they provide an easy path for the lightning to ground.

If you have clay soil at your site that stays moist all year and you have a ground rod at each tower leg or at the guy anchors and tower base, you probably have an adequate ground. We recommend that all of the ground rods be connected together with a buried, bare conductor and that the same conductor continue on to the controller's grounding system.

A good grounding system is necessary but not sufficient for protecting your system from lightning. Even with good grounding, your tower can still be hit, and even a nearby strike can induce high voltage in the tower and wires. A good lightning protection system (LPS) helps protect your wires and electronics from these induced voltage surges and from most direct hits.

An LPS provides a path between your electrical wires that limits the voltage difference between any two wires and between any wire and ground at that location. The insulation on your wires should withstand 2,500 volts. We first place a lightning arrestor at the top of the tower to protect the wire run down the tower, which should be inside a tower leg or inside a grounded metal conduit. This will reduce the induced voltage from a lightning strike coming down the tower or a nearby lightning strike.

Because there will still be a voltage surge in the wires, an arrestor is needed at the base of the tower to dissipate it. If the tower receives a direct hit, there will be thousands of amps (20,000 A, on average) in the strike. The first lightning arrestor will only limit the voltage to about 2,000 volts at that current, so further protection is needed.

We also place a lightning arrestor just before the controls. At this point, the voltage and current from even a direct hit have been greatly reduced by the first two devices, and the wire run will have slowed the rate at which the voltage rises. This last device can now limit the voltage and current to a value that the capacitors in the controller will absorb without damage.

The whole system is designed to protect the inverters and other controls from 90% of direct hits. Each device is rated to absorb 80,000 amps. In addition to the three devices between the wind generator and the controls, an arrestor at the AC panel is installed to protect from voltage surges coming from the utility or home wiring.

Our LPS was designed to survive 90% of direct lightning strikes without damage to the equipment, and offers a warranty for lightning damage to the inverters and controls we sell with our turbines. Some customers elect to purchase a single device and place it at the base of the tower or at the controller. This approach will provide some protection, but has no warranty. The LPS for the ARE110 lists for $2,500, and includes four high-quality arrestors and extended warranty coverage. A single arrestor lists for $594. You can purchase other devices for less than $100 each, but when we tested a couple of inexpensive units, they did not pass current until approximately 7,000 volts—much too high for adequate protection.

When purchasing a lightning arrestor, make sure that it is MOV- or SOV-based. (Metal-oxide and silicon-oxide varistors are voltage-dependent resistors, designed to break down at specific voltages, shunting a lightning strike to ground.) Also find out the device's current rating. The average lightning strike is 20,000 amps, so a 10,000-amp-rated arrestor will not protect your system from the "average" lightning strike. Place your bets.

Robert Preus, Abundant Renewable Energy • Newberg, Oregon

"Metal-oxide and silicon-oxide varistors are voltage-dependent resistors, designed to break down at specific voltages, shunting a lightning strike to ground."


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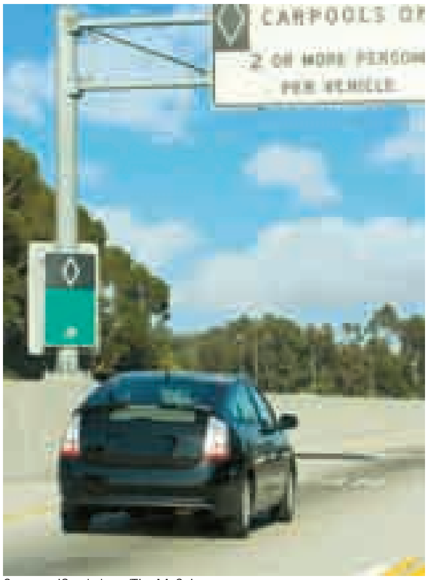

Courtesy iStockphoto/Tim McCaig

Carbon Choices

I am hoping you can provide some direction on how best to reduce our family's carbon footprint and still stay within a budget. My wife and I are approaching retirement and plan to build a home on a lake in northern Wisconsin. We'll be driving a few hundred miles quite regularly to visit grandchildren. It seems obvious that we will want to make our new south-facing home as energy-efficient as possible. However, it is not easy to decide on whether to spend the rest of our energy-efficiency budget on:

- **The most efficient vehicle we can find (our current vehicle gets 36 mpg on the highway)**
- **A geothermal heating system to minimize or eliminate our natural gas heating system**
- **A solar water-heating system**
- **A solar-electric system to minimize electrical bills (even though northern Wisconsin doesn't have an abundance of sunshine)**
- **Cross-country skiing more and snowmobiling less**

What's the best way to decide between all these alternatives? Is there any way to really know what the CO_2 impact is of these decisions? I suspect that many people just getting involved in this have these same questions about where to begin. What resources can you share with your readers to help prioritize our efforts?

Larry Roth • Combined Locks, Wisconsin

There's no one-stop place to get the answers you need, but here's a little advice on each of your approaches.

Efficient Vehicle. The fact that you already own a relatively fuel-efficient vehicle says to me that you could put this decision off for a while. Based on the driving habits of a typical American, switching from a 36-mpg Toyota Yaris to a Prius hybrid would save about 1.2 tons of CO_2 and 130 gallons of gasoline per year. (You might conclude that by hanging onto your relatively efficient current car you will delay the expenditure of resources that would go into a new and even more efficient car. I'm inclined to think that anything that gets additional efficient cars into the mix sooner is probably good. And I hope you would sell your current efficient car to some suffering gas-guzzler owner and save even more carbon.)

These are good improvements, but I would still concentrate on the new house for now. See "Resources" for information on each approach.

Geothermal Heat Pump. Before you consider a geothermal heat pump for your new home, focus on building only as large as you need. Incorporate passive solar heating and cooling, lots of insulation, and the most efficient windows you can buy. Add good air sealing and the most efficient lighting and appliances you can afford.

As an example of how powerful this approach can be, an 1,800-square-foot, well-insulated home getting 30% of its heat from passive solar with efficient appliances and lighting saves about 10 tons of heating-related CO_2 and 5 tons of electricity-related CO_2 per year compared to a conventionally built 3,000-square-foot house—an 80% reduction!

A very efficient geothermal heat pump powered by the very dirty U.S. electricity grid results in little or no CO_2 reduction compared to an efficient gas furnace, although it might be a good investment if the home has solar- and/or wind-electric systems to offset the heat pump's electricity usage. You might also consider an efficient wood stove or masonry heater for low-carbon heating.

Solar Space & Water Heating, Plus Solar (or Wind) Electricity. Consider solar water heating, active solar space heating, and a solar-electric system—in that order. If the budget does not allow for these now, carefully design for adding these systems later but install the plumbing and electrical infrastructure for them during construction. You can literally pay for adding solar energy out of your ongoing energy savings.

Cross-Country Skiing vs. Snowmobiling: Cross-country skiing is a win for both your health and the planet.

Finally, another factor to consider is that your new home will most likely still be in use 100 years from now. The energy-saving features you include will continue saving CO_2 for your grandkids' grandkids. Building a new home is a great opportunity to do good for many years to come.

Resources to help evaluate each energy-saving approach:

The *Home Power* article series on my family's "half program" starting in *HP118* outlines energy and CO_2 reductions for quite a few real-world projects.

The Carbon Busters Home Energy Handbook, by Godo Stoyke (New Society, 2007) provides energy and CO_2 reduction estimates for even more projects.

The www.hybridcars.com Web site has a gas mileage impact calculator to compare fuel consumption and CO_2 emissions for any two cars.

These home heat loss and insulation upgrade calculators help you evaluate the energy and CO_2 benefits of insulation and window upgrades. www.builditsolar.com/References/Calculators.htm

Home Energy Efficient Design is easy-to-use home energy simulation software to analyze and tweak your home's design. www.aud.ucla.edu/heed

Infinite Power has a general-purpose carbon calculator. www.infinitepower.org

Size your PV system with PVWatts, a solar-electric system calculator. http://rredc.nrel.gov/solar/codes_algs/PVWATTS/

Gary Reysa • Bozeman, Montana


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Hail Damage

How can I protect PV modules from hailstorms without drastically reducing their output? Should I add another layer of glass or plastic to protect them?

Bette Lowery • Roundup, Montana

The glass covering on solar-electric modules is quite thick, and also tempered. Only occasionally do we hear of hailstone damage, and that is for the rare hailstones that are bigger than golf balls. I have heard of baseball-size hailstones not damaging modules, though obviously you cannot count on that. Under standard test conditions, PV modules are subjected to the equivalent force of 1-inch-diameter hailstones at a terminal velocity of 50 mph.

PV modules are usually covered under your home insurance policy, so if that policy covers other hail damage, it should also cover your solar-electric modules. A quick call to your insurance agent is a good idea and, if needed, you can add the PV system to your policy.

Adding an additional layer of protection over the modules will seriously reduce their output. I suspect that the reduced output will be financially worse than the rare replacement.

Michael Welch • *Home Power*

Courtesy iStockphoto/Chris White

Legionnaires' Disease

I recently installed a solar hot water system in my home, but have some concerns about the possibility of the tank being a breeding ground for Legionnaires' disease. The bacteria that cause Legionnaires' disease grow best at temperatures between 70°F and 100°F. (The bacteria can be destroyed with water temperatures between 120°F and 140°F.) The condition may be worse if you are on well water, which I am sure a good number of *Home Power* readers are.

I'm worried that a dual-coil SHW tank may be the perfect breeding ground for the bacteria in the winter. I have a 120-gallon solar tank, and during the winter the solar hot water system is barely active, so a strata of water will be at the ideal breeding temperature. Should I be concerned?

Joe Smith • Middlebury, Vermont

Courtesy iStockphoto/Jim Pruitt

We know of no documented case of this disease coming from a solar hot water system. I trust the National Institutes of Health (NIH) much more than other Web sites I found when searching for "causes Legionnaires' disease" (see www.nlm.nih.gov/medlineplus/ency/article/000616.htm). That search pulls up at least one company promoting tankless water heaters over tank-style water heaters by claiming to be immune to fostering the disease-causing microorganisms. In marketing circles, this sort of rhetoric has a name—"buy or die marketing." The NIH has nothing to say about solar hot water systems as a cause, nor conventional water heaters. In fact, it looks like visiting a hospital might be more dangerous, since their air conditioning systems are mentioned specifically.

However slight, the potential for infection does exist in all systems where water is stored at temperatures lower than 120°F, and more research needs to be done to determine possible risks.

Chuck Marken • *Home Power* Solar Thermal Editor

"PV modules are usually covered under your home insurance policy, so if that policy covers other hail damage, it should also cover your solar-electric modules."

Batteries on Concrete

Several folks have told me not to let batteries sit on concrete. Why is that? Is it because the cold concrete would cool the battery too much?

Steen Hvidd • Dolan Springs, Arizona

Your question is a frequent one. Many people have the impression that when batteries sit on concrete, energy "leaks out" or they are ruined. The short answer is that letting modern batteries sit on concrete does not harm or discharge them in any way.

However, this legend is historically based in fact. The first lead-acid batteries consisted of glass cells that were enclosed in tar-lined wooden boxes. A damp concrete floor could cause the wood to swell, breaking the glass inside.

The Edison cell (i.e. the nickel-iron battery) that preceded the rubber-cased battery was encased in steel. Those that weren't isolated in crates would discharge into concrete quite easily. Later battery cases used primitive hardened rubber, which was somewhat porous and could contain lots of carbon. A moist concrete floor combined with the carbon in the battery cases could create electrical current between the cells, discharging them.

None of this is a problem with modern batteries—safe in their hard plastic shells. In fact, concrete is generally an excellent surface on which to place a battery bank. The electrolyte in a battery sitting on an extremely cold floor with very hot air around it could stratify, causing damage from sulfation; whereas concrete provides good thermal mass to buffer any temporarily extreme temperatures in the battery compartment.

Energy *can* in fact "leak" out of battery banks—though in different ways. The first is from current between the battery terminals, caused by dirt, dust, and grime becoming carbonized (and therefore electrically conductive) from acid released from the cell. This is easily preventable. Use a clean rag to carefully clean the tops of the battery cases every time you perform your regular battery bank maintenance routine.

The second way happens to all batteries—it's called "self-discharge." Due to reactions within the plates, all lead-acid batteries will lose part of their charge over time. The warmer the battery compartment and the older the battery, the higher the self-discharge rate. An L-16 battery will lose 4% of its charge per week at 80°F.

This brings us back to your original question, where you mentioned battery bank temperature. There are multiple electrochemical reactions going on inside any battery, all the time. Some are good (storing and releasing energy), and some are bad (self-discharge, sulfation). *All* of these reactions happen faster when the battery is hot, and slower when it's cold.


Courtesy Tracy Dahl

Amy Dahl shows off a well-made, insulated battery box.

Cold temperatures don't damage lead-acid batteries unless the battery is heavily discharged and exposed to freezing temperatures. In that case, the electrolyte (which is mostly water when the battery is at a low state of charge) can freeze and crack the case. On the other hand, a fully charged battery can withstand -30°F or lower without a problem.

However, since cold temperatures slow the desirable chemical reactions too, the amount of energy a battery can release at any given time is drastically reduced when the battery is very cold. That's why it's more difficult to start your car on a frigid morning. And it also takes more energy to charge a cold battery than a warm one—cold batteries are less efficient at both charging and discharging. At the end of the day, a good rule is that batteries like the same temperatures that humans do, between 60°F and 80°F.

Dan Fink, ForceField • Fort Collins, Colorado

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"All lead-acid batteries will lose part of their charge over time. The warmer the battery compartment and the older the battery, the higher the self-discharge rate."

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Shading Analysis

Various methods have been described for determining whether obstructions near a proposed solar installation will shade the collectors or PV modules at any time of the year. These methods involve either performing calculations, using sun path diagrams, or using other tools such as the Solar Pathfinder. I found these methods rather cumbersome or expensive, so I came up with a simple, highly visual, and fun way of determining actual shading on the site. Freely available tools are used.

"The SketchUp method does not give quantitative information, but it gives a quick visualization of the actual shadows created by landscaping and other features at various times of the day and year."

1. Download Google SketchUp, a free, easy-to-use 3-D modeling program. I had never used a 3-D modeling program, but in a very short time, I was able to create my model and had fun doing so. Also download Google Earth, a free program that lets you explore the world through maps and satellite photos. (Find both at www.google.com/options.)
2. In SketchUp, model the site where the solar modules or collectors are to be located, including surrounding structures and obstacles. The model can be as simple as a small section of roof or, in my own case, a rather elaborate model that I will also be using for other purposes.
3. Now for the cool part. Launch Google Earth and navigate to the site of the solar installation. Switch back to SketchUp and, under the Tool menu, select "Get Current View." SketchUp imports a snapshot of the Google Earth window and sets the latitude and longitude of the 3-D model to the correct values, so the sun's position and path will be correct.
4. SketchUp allows you to simulate sunshine on the site at any time of day with their Shadows menu. Shadow studies can be done by moving the Date and Time sliders in the SketchUp window.

The computer screenshot shows my model superimposed on the Google Earth snapshot. I have adjusted the date and time to December 31 at noon. You can see that, in this case, the chimney does not shade the first solar collector, but the first collector shades the second.

I've found that some solar installers use the SketchUp method when laying out arrays around chimneys, hip roofs, dormers, etc. It's excellent for making sure that specific building features don't shade an array.

The method is completely free (apart from the time needed to create a model), and I had fun learning to use the software to create a 3-D model of my house. Note that fairly precise measurements of the structure are needed for accurate modeling.

The SketchUp method does not give quantitative information, but it gives a quick visualization of the actual shadows created by landscaping and other features at various times of the day and year. From that, a good estimate of your shading issues can be obtained.

Simon Politzer • Mount Prospect, Illinois

Bucket Hydro

I developed a 5-gallon bucket generator as a low-cost hydro-electric system for the developing world. The picohydro systems that I saw for sale in the United States were very expensive, so I sought to create a system that would be affordable to low-income people. With this economy in mind, my system uses only the generator, one standard lead-acid car battery, an inexpensive solar dump-load regulator, and a 100-watt inverter. For first-world applications, the system could use a large battery bank and provide considerably more usable electricity, but in the interest of creating an affordable solution, a single, standard car battery was used in our tests. As in an automobile, the battery experiences minor fluctuations in charge, but is never drained very much.

During trials in Guatemala, we used another 5-gallon bucket that was fitted with hardware cloth to serve as a trash rack. A 2-inch-diameter penstock was then run from the trash rack, and down the mountain for a total drop (or head) of 98 feet. When the turbine was hooked up, it was generating about 60 watts. Ten cell phones could be charged at a time without discharging the battery.

The generator uses a permanent-magnet alternator (PMA) and off-the-

(continued on page 26)

CAPTAIN SOLARIAN*

*Simulated picture. Please do not approach the Captain with any flammable or ignitable contents on your person. Doing so may result in personal injuries to yourself and those around you, which holds yourself liable in any accidental occurrences.

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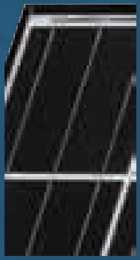

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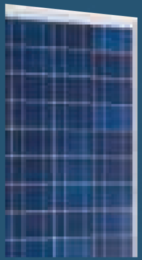

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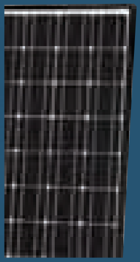

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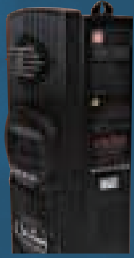

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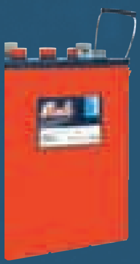

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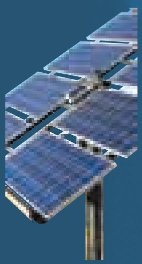

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Wattsun tracker frames are precisely engineered for strength, are fabricated from steel and structural aluminum and disassemble for ease in shipping and installation.
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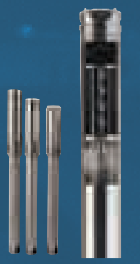

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shelf PVC pipe and hardware. Everything except the PMA is readily available at almost any hardware store. The turbine itself is made of eight 45-degree PVC elbows, cut in half and mounted with rivets to part of a bucket lid. The PMA is mounted to the lid of the bucket using threaded rod. A manifold is mounted to the lid of the bucket and plumbed through, culminating in four nozzles also made from PVC. While a considerably more efficient generator could be made using a Pelton or Turgo runner, the idea behind the design was to make something that could be easily constructed and serviced with readily available materials. The PMA with cooling fan was about $360, and the other hardware and PVC was about $40, totaling $400.

Our long-term goal is to incubate microbusinesses that charge cell phones in areas where there is no electricity. We are also exploring the idea of microlighting using high-output LEDs.

Sam Redfield • West Shokan, New York

Real-World Wind Costs

"I would like to suggest that when including estimated system costs, you print a range of cost or suggest the higher end and more accurate real-world cost."

I enjoyed reading "How Tall is Too Tall?" in *HP126*. I do have a concern about the published estimated system prices. We put up the first Skystream in Washington state, and others since. We also work in Oregon. Now we are dealing with possible additional cost for Washington state electrical permitting, an engineer-stamped approval for the tower plans in Oregon, and other costs depending on location. Our price for an installed Skystream on a 64-foot ARE tilt-up tubular tower is close to $20,000.

I would like to suggest that when including estimated system costs, you print a *range* of cost or suggest the higher end and more accurate real-world cost. Customers who read the article will get an unrealistic estimate of the installed cost.

If we can put the system in for less than what they have read, we are heroes. If our quote comes in higher, it raises a red flag and necessitates a lot of explaining that would not be necessary otherwise.

I don't know how a Skystream on an ARE 64-foot tilt-up tower can be installed by a professional in Oregon or Washington for your estimated $14,600. At least not while making enough profit to stay in business and offering a two-year warranty. We have already had to bring down one of our installed Skystreams for repair, and service call expenses are not included in its warranty. Perhaps in the future you might call some of the installers and list a range of stated installed costs.

Bob Skinner, Seraphim Energy Inc. • Goldendale, Washington

I have to say that I was not surprised to see an e-mail concerning the installed cost estimates in our recent article on wind tower economics. Many, if not all, of the installed costs have gone up since we worked up the estimates for the article in fall 2007. It's probably time to rework the estimates.

In June 2007, we solicited installers to provide us with accurate installed costs for a variety of tower types and heights. We used actual installed cost reports from several installers for the tower and turbine combinations we had data for. We did not have actual data on many of the combinations, including the Skystream on the 64-foot ARE tilt-up tower, so we had to do some estimating. We wish we could have used a range of costs, but the main idea was to illustrate how tower height affects both the installed cost and energy output, so we had to pick a number to demonstrate the economics.

Some lessons we have learned in the small wind industry are:

- Be very conservative in your wind resource and energy output estimates.
- Add a healthy "stuff happens" factor to installed cost estimates—things always cost more and take longer than you think.

The cost table in the article probably should have carried a disclaimer that installed costs vary greatly and that the trend is upward, so buy now!

Brent Summerville, Appalachian State University • Boone, North Carolina

> *"When I started trying to tap the wind, my choices were swayed by the initial investment—I had no idea what the total cost of doing business was."*

North Winds are Tough!

I live in a very remote area of Alaska, where weather conditions are rugged at times. I want to share a few recent experiences I've had with my wind systems, to better advise your readers without damaging small wind's image. A lot of what has happened to me recently could be viewed as totally negative, but I prefer to learn from it.

A few months ago, we had a five- to six-day windstorm where I recorded winds as high as 96 mph on my 26-foot-high rooftop anemometer. I assume the wind speeds were significantly higher on the tops of the 50- to 80-foot towers nearby. You can see from the photo what happened during one evening (blades and alternator are missing). During that period, my rooftop anemometer (150 yards downhill from the towers) recorded a high of only 84 mph, but I was awakened during the night with sharp gusts that really wracked the house—I am sure the recording interval of my weather station missed those. One of the clues was the grass hanging from the crosspiece at the 63-foot level of one tower.

My reason for choosing the medium-duty turbines I purchased for my neighbors was the fact that my 10-year accumulated data showed a 10.4 mph average wind speed. My mistake was thinking that a second-story rooftop where the averages were recorded reflected the wind speeds up on a tower. For example my last month's average for my rooftop anemometer was 14.4 mph, while my 63-foot-level anemometer measured 18.2 mph. My other mistake was thinking that average wind speed should be the sole determination for turbine sizing—it should not be. I was aware that we have wind speeds above 75 mph at least monthly, and that should have been taken as a warning.

Another problem was a more basic siting issue. The location of the present towers is just downwind from a 35- to 40-foot sloped riverbank, in the prevailing southeast winds. I have video footage of 80 mph winds whipping gravel in a very dramatic vortex/plume at least 50 feet above the bank. I should have been concerned about locating even a bulletproof, "heavy metal" wind turbine in the path of that monster turbulence.

Years ago when I started trying to tap the wind, my choices were swayed by the initial investment. I had no idea what the total cost of doing business was. It is now my belief that the more harsh your conditions, the more the total cost of doing business will be. Invest well to produce well for the long term.

Bob Dreeszen •
Outlet Lower Ugashik Lake, Alaska

Solar Motivations

We installed our grid-tie PV system for many reasons, most of which you cover in your magazine every month. However, we don't see you mention in so many words our primary reason for installing our system—fear. Fear is not a popular motivator, especially with the typical *Home Power* reader. But fear has been the source of many bad decisions by the United States in the last eight years. When we saw gasoline prices double a few years ago, with no response from the U.S. government, we were pretty sure that electricity prices would be next. At the time, our electricity cost $0.085 per kilowatt-hour. What happens if that shoots up? Is it likely to shoot up? We felt like this could happen very easily and that our state and federal governments would do nothing to prevent it.

Although PV systems never generate the amount of electricity that you expect, our system here in Cottonwood, Arizona, is doing a pretty good job. The intense heat we have degrades the performance a bit—but after some number crunching, including incentives, I calculated a payoff time of 25 years at $0.085 per KWH, after which time parts of the system may need replacing. If electricity prices stay the same, it would be a wash financially. That's not a bad deal considering all the other benefits we get from our PV system.

But as we feared, rates have gone up to $0.128 per KWH—just over a 50% increase—in the last two years. Our last electric bill (June 2008) was $44, mainly because we've started using the central air conditioners as the temperature creeps up to more than 100°F.

Although fear was our main motivator, we are happy with our investment and our introduction into the green movement. We'll be doing more to conserve and save in the near future.

Chuck & Karen Conover •
Cottonwood, Arizona

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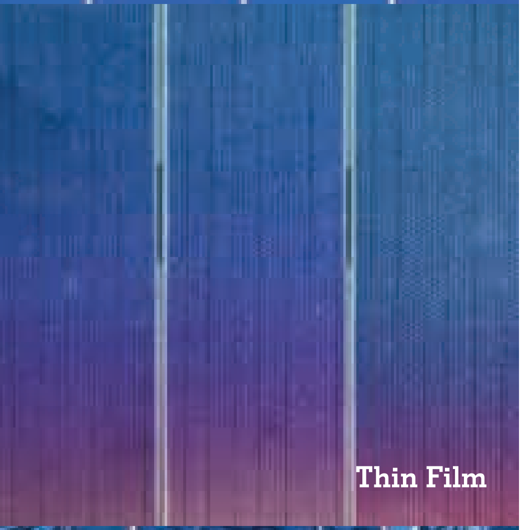
Single-Crystalline


String Ribbon


Thin Film


Multi-Crystalline

PV Energy Payback

by Justine Sanchez

Photovoltaic technology is a fantastic miracle of science that silently converts sunlight into streaming electrons that can be used to do work. While sunlight magically falls from the sky, PV modules and their associated components do not—each consumes energy and resources along every step of the production process, from material harvesting to manufacturing to assembly and shipping.

A common myth about PV technology is that it takes more energy to produce a PV system than the system will produce in its lifetime. Thankfully, this is not the case. Recent studies of energy payback time (EPBT) estimate that it takes a PV system one to three years to produce the same amount of energy that it took to manufacture it. Given that a PV system will continue to produce electricity for 30 years or more, a PV system's lifetime production will far exceed the energy it took to produce it. Here's an in-depth look at the embodied energy along the way.

Module Manufacturing Methods

A batteryless grid-tied PV system has many parts—modules and mounts, inverter(s), and wiring components (including conduit, fittings, electrical boxes, wire, and overcurrent protection). Each part of a PV system takes energy to both produce and transport (embodied energy), but of all of them, the modules require the most energy to manufacture—about 93% of the entire system.

Single-crystal (monocrystalline) PV cells are commonly manufactured using the Czochralski (CZ) method, where a "seed" silicon crystal is dipped into purified molten silicon and slowly raised out of the pot. As the seed crystal is raised, the molten silicon cools and solidifies into a single cylindrical crystal around and beneath the seed crystal. This process is referred to as "pulling" or "growing" an ingot. Thin slices—about 200 microns (0.008 inches) thick—are cut from the ingot and, with the addition of an antireflection coating and a wire grid to collect the electrons, become individual PV cells. To create a module, several cells are laid out and joined together electrically. Finally, the module is given a protective backing, topped with a glass covering, and then sealed and framed with extruded aluminum.

Each step and material used in this manufacturing process requires energy. Purifying and melting the silicon uses a lot of heat energy. There is also a fair amount of energy used to make the aluminum module frame, as well as the coatings and glass. Purifying and growing the silicon crystal, along with the embodied energy of an aluminum frame, make up the lion's share of energy involved in producing a single-crystal PV module.

Multicrystalline PV cells are generally made using a casting process, where molten silicon is poured into a square mold and left to solidify. This process creates many crystals within an ingot.

The ingot is sliced into thin square wafers to produce PV cells in the same way as the single-crystal process. Once the cells are created, the manufacturing proceeds as for monocrystalline modules. You can spot a multicrystalline PV module by its varied, glittering crystal surface, compared to very uniform-looking single-crystal silicon cells.

Multicrystalline PV modules do require less energy to produce than CZ-produced monocrystalline PV modules partly because the cooling process for the cast ingot uses less energy. The energy payback times for multicrystalline PV systems are about 15% less than for monocrystalline PV systems.

String Ribbon Silicon. Another way to produce a crystalline PV module is to grow thin ribbons of silicon that can be cut into individual cells. One method that produces these types of cells pulls two parallel wires out of a vat of molten silicon. As the wires are pulled up, a thin sheet of silicon the width of a finished cell stretches and hardens between them, much like soapy film stretches between the sides of a child's bubble wand. Because the ribbon silicon sheet is so thin, it does not need to be sliced as ingots do, but is sectioned into cell-sized lengths to make individual PV cells. The ribbon silicon cells are formed into modules the same way as the monocrystalline and multicrystalline PV technologies.

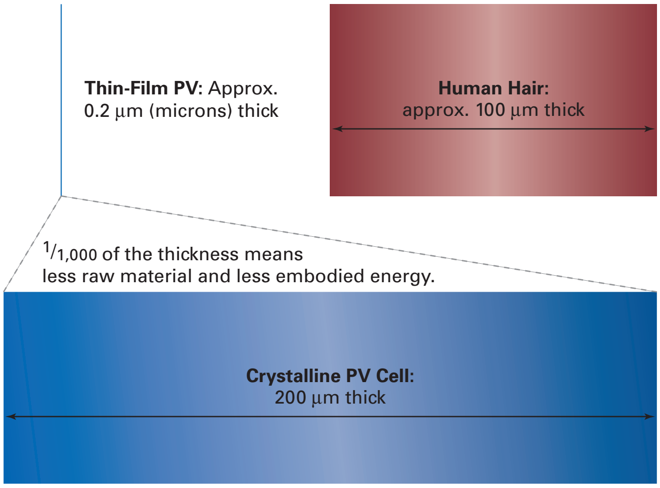
Courtesy www.nrel.gov

The energy embodied in a PV module includes not only the energy to produce its basic materials, but the energy of the manufacturing process as well.

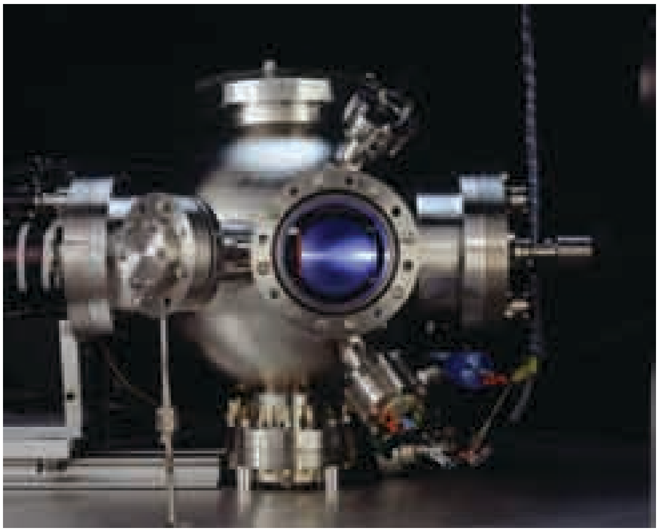
The ribbon technique reduces the energy and silicon crystal waste associated with sawing the wafers (kerf loss) from a crystalline ingot, reducing the energy payback time compared to monocrystalline by about 25% and multicrystalline PV by approximately 12%.

Thin-film PV modules use a deposition process, in which different layers of the PV cell are sprayed directly onto a substrate. Since there are no individual crystals to break, this substrate can be flexible and virtually any shape or size. The PV cells are completed after all the layers of the semiconductor material have been applied to the substrate by scribing the entire module into individual cells with lasers. Thin-film modules use a transparent conducting oxide (also applied as a layer in the deposition process) for electrical contacts, instead of an unbendable metal grid as crystalline cells.

Crystalline vs. Thin Film Cell Thickness



The thin-film deposition process uses less energy—and less energy-intensive silicon—than a crystalline PV cell.



Courtesy www.nrel.gov

Courtesy www.evergreensolar.com

The Evergreen Solar manufacturing process grows string-ribbon crystals at the thickness of the finished cell, saving silicon waste and reducing embodied energy by as much as 25%.

The production process for thin-film PV modules uses considerably less energy than crystalline PV—there is no vat of molten silicon brewing, and there are no ingots to be sawed. The most energy-intensive aspects of manufacturing a thin-film PV module are usually the deposition process, the substrate itself, the aluminum frame, and the glass or plastic covering. The EPBT for thin-film PV systems is about 50% less than for crystalline PV systems.

A single-crystal ingot makes the most efficient PV cells, but much of its raw material is wasted to saw kerf. Waste is recycled but must be remelted, crystallized, and sawn again—using more energy.

Courtesy www.solarworld-usa.com

Calculating Energy Payback

EPBT is calculated by dividing the energy needed to produce a PV system ("specific energy") by the system's energy generation rate:

EPBT (Years) = Specific Energy (KWH) ÷ Annual Energy Generation (KWH/year)

Note that "specific energy" accounts not only for the direct energy required to produce PV systems, but also the embodied energy of the raw materials used in manufacturing all the parts of the PV system.

A study conducted by CrystalClear, a research and development project on advanced industrial crystalline silicon PV technology, gives 2006 EPBT values for complete rooftop, grid-tied systems. The study includes the EPBT for balance of system (BOS) components (racks, inverters, wires, etc.) and assumes a system efficiency of 75% to account for losses from module temperature, wiring, and inverter inefficiency. The study uses average solar data for southern Europe, which is estimated at 1,700 KWH/m^2 per year. The U.S. average is slightly higher at 1,800 KWH/m^2 per year, which means EPBT for U.S. installations is even shorter.

The study shows the EPBT for standard, single-crystalline module PV systems to be two years. For PV systems using multicrystalline modules produced by the casting method, the EPBT is calculated at 1.7 years. PV systems with modules produced using the ribbon method reduced the EPBT to 1.5 years.

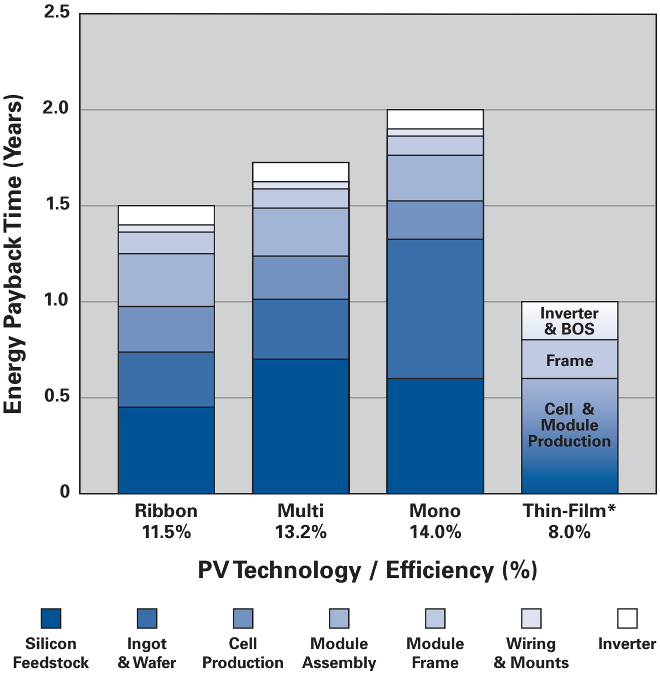
EPBT values for thin-film module-based PV systems were reported in a 2004 study. While there are several types of thin-film PV technologies—the most common are amorphous-silicon (a-Si), cadmium telluride (CdTe), copper indium diselenide (CIS), and copper indium gallium diselenide (CIGS)—the 2004 study highlights the CdTe modules and shows an EPBT of 1.0 years.

Future EPBT Projections

In 1975, EPBT for most PV modules was estimated at 20 years. Today, it only takes an average of three years or less for PV systems to produce the energy required to offset what it took to manufacture the systems, and EPBT continues to decrease each year.

PV manufacturers are always seeking to reduce manufacturing costs, through reducing the amount of silicon required, improving PV cell efficiency, experimenting with new materials, and by utilizing new production methods. Most cost-reduction strategies will also reduce energy payback time. In their EPBT research on the CrystalClear project, authors Erik Alsema and Mariska de Wild-Scholten estimate "that developments underway to reduce costs will also result in a reduction of the energy payback time of a PV

PV Energy Payback by Technology



Notes: Energy payback time of PV systems in 2006, rooftop systems in southern Europe, irradiation 1,700 KWH/m²/year, system efficiency 75%. *2004 study on Thin-Film (CdTe) lumped all BOS together, not separating wiring/mounts and Inverter.

Source: Erik Alsema and Mariska de Wild-Scholten, "Reduction of Environmental Impacts in Crystalline Silicon Photovoltaic Technology– An Analysis of Driving Forces and Opportunities," November 2007.

installation (in southern Europe) from 1.5 to 2 years presently, to well below one year." With higher average peak sun-hours in the United States, future EPBT for modules installed here will be even lower.

Variations in Energy Payback

Available sunlight. EPBT calculations are heavily influenced by how much sunlight a PV system will receive. The more sunlight received, the more KWH the PV system will produce—and the faster the PV system will offset the energy it took to manufacture it. The 2006 study reported EPBT of one to two years based on an average of 4.7 peak sun-hours received in southern Europe. If you live in a sunnier climate, then the energy payback time will be less. For example, a system installed in Grand Junction, Colorado, which averages 5.8 peak sun-hours daily, can cut its EPBT by more than 23% under a southern European site. However, the converse is true as well. If you live in a cloudier climate, the PV system's EPBT will be longer. The current overall worldwide average EPBT of one to three years (rather than one to two years for southern Europe) accounts for cloudier locations across the globe.

PV System Performance & Maintenance. While PV installers and system owners do not have much control over the manufacturing process of PV modules or the peak sun-hours available, they can influence the energy payback times of their systems with good system design and maintenance.

Think Globally... Buy Locally

The location of a PV module manufacturing facility is another energy payback factor. An increasing number of modules come from China and Japan, which increases the embodied energy due to shipping. So just like you may buy local foods or goods for environmental and social reasons, you may also want to consider using locally produced PV modules and components.

U.S. PV Module Manufacturers

Manufacturer	Model Numbers (Cell Type)	Facility Location
BP Solar	Not specified	Frederick, Maryland
EPV Solar	EPV40 (thin film a-Si)	Lawrenceville, New Jersey
Evergreen Solar	ES-180-SL (ribbon) ES-190-SL (ribbon) ES-195-SL (ribbon) ES-A-200-fa2 (ribbon) ES-A-205-fa2 (ribbon) ES-A-210-fa2 (ribbon)	Marlboro, Massachusetts
GE Energy	Not specified	Newark, Delaware
Schott	ASE 300 (ribbon) ASE 270 (ribbon) ASE 250 (ribbon) SAPC 170 (multi) SAPC 175 (multi)	Billerica, Massachusetts; Memphis, Tennessee
Sharp	62W USA (poly) 65W USA (poly) 130W USA (poly) 170W USA (poly) 175W USA (mono) 176W USA (poly) 198W USA (poly) 216W USA (poly) 224W USA (poly)	Modules assembled in Memphis, Tennessee (cells made in Japan)
SolarWorld	SW155 (mono) SW165 (mono) SW175 (mono)	Camarillo, California
United Solar	PVL68 (thin film a-Si) PVL124 (thin film a-Si) PVL136 (thin film a-Si) PVL144 (thin film a-Si)	Auburn Hills/ Greenville, Michigan

Note: Included are UL-listed modules currently available in the U.S.

Good site analysis reduces or eliminates PV array shading and aims for high system efficiency. (See "Choose the Right Site" in *HP115*.) And adequately sized wires will reduce voltage drop and thus increase power output over undersized wiring. Providing adequate airflow around modules to reduce voltage loss due to increasing cell temperature will increase power output. Finally, carefully matching the array size to the inverter and local temperature conditions will help squeeze the last available energy out of a system.

Electricity derived from coal and natural gas will never be able to outweigh the energy and continual resources required to produce it.

Systems also require periodic maintenance. Trim growing trees or shrubs that may start to shade the array. Keeping modules dust- and debris-free will help keep performance at its peak. A quick system output check can confirm that all is in good working order. (For tips on maximizing PV system performance, see "Pump Up the Power" in this issue.) Keeping your PV system in optimal working order will minimize PV system energy payback time, decrease the use of fossil fuels and associated CO_2 production, and reduce the money you will need to spend on utility power or backup generator fuel.

Conventional Power vs. PV

Electricity derived from coal and natural gas will never be able to outweigh the energy and continual resources required to produce it. Additionally, there are the associated environmental impacts of global warming and air, water, and soil pollution due to the emissions from fossil-fuel based power plants, and the environmental impacts of mining, drilling, and transporting coal and natural gas.

Unlike conventional energy sources, PV systems produce clean electricity for decades after achieving their energy payback in three or fewer years—this is truly the magic of PV technology.

Access

Justine Sanchez (justine.sanchez@homepower.com), is a NABCEP-certified PV installer, *Home Power* technical editor, and Solar Energy International instructor. Justine lives, works, and teaches from an on-grid PV-powered home in Paonia, Colorado. Her multicrystalline PV modules fully paid back their embodied energy eight months ago.

Resources:

Alsema, Erik & Mariska de Wild-Scholten. 26–27 November 2007. "Reduction of Environmental Impacts in Crystalline Silicon Photovoltaic Technology—An Analysis of Driving Forces and Opportunities." Materials Research Society, Fall 2007 meeting, Symposium R, Boston.

"PV Payback," Karl Knapp & Theresa Jester, *HP80*

Thanks to Erik Alsema, Karl Knapp, and project CrystalClear (www.ipcrystalclear.info) for their help and resources.

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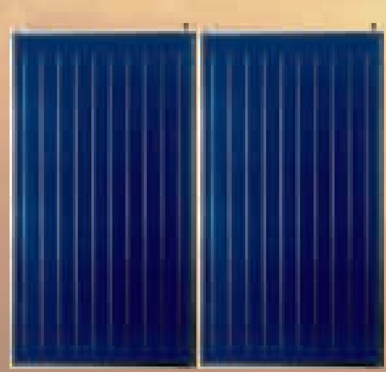

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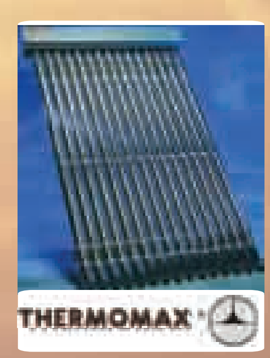

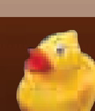

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The owners of this Oregon home use both solar electric and thermal—making it cheaper to offset their energy consumption with renewable energy.

PV vs. Solar Water Heating

Simple Solar Payback

Solar energy systems hang their hats on payback. Financial payback is as tangible as money in your bank account, while other types of payback—like environmental externalities—are not usually calculated in dollars. There's no doubt that photovoltaic (PV) and solar hot water (SHW) systems will pay you back. Maybe not as quickly as you'd like, but all systems will significantly offset their cost over their lifetimes. Here we'll try to answer: Which system will give the quickest return on investment (ROI)?

Financially, solar pool heaters and off-grid PV systems have the quickest payback of all home-scale solar energy. Solar pool heaters pay back in three to ten years. Off-grid PV systems can have an immediate ROI if they eliminate the need for costly utility-line extensions. However, not everyone uses those kinds of systems. Most U.S. homes have utility-generated electricity and are without swimming pools. The two most common solar energy systems are utility grid-tied PV and domestic SHW. These systems can reduce your utility bills and cut your carbon footprint. Let's take a closer look at the economics of the two technologies.

Payback Ground Rules

No subsidies or incentives have been factored into these payback scenarios—the paybacks are based on simple rates of return and are used to show the relative value of each technology based on its estimated cost and energy production. The scenarios do not include system maintenance, although some maintenance will probably be required over the life of each. The payback periods will vary with location depending upon the climate, the cost of utility-generated electricity, and installation costs.

Solar System Costs & Efficiencies

Technology	Collector or Module Efficiency	System Efficiency	Cost	System Cost Per KWH*
SHW: 64 sq. ft. of collectors + 80 gal. water heater	50%–70%	35%–50%	$8,000	$0.09
Grid-tied PV: 2 KW	5%–19%	4%–13%	20,000	0.27

*Over 30 yrs. in Richmond, Virginia; maintenance costs not included

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ROI calculations can be much more complex than the simple methods used here. We left out the future value of the initial investment and the tax-free nature of solar returns and just tried to keep this as simple as possible. Our methodology concentrates on the comparison of grid-connected PV and SHW systems. Information similar to return on investment is an integral part of information given to policy makers to support the need for incentives to offset the initial cost of the solar energy systems. Quicker payback periods that are incentive-driven through local rebates and tax credits have resulted in big increases in market penetration. Without dramatically higher utility rates and/or more attractive incentives, solar energy systems in most of the United States will have a tough time being installed on the basis of economic payback alone.

by Chuck Marken & Justine Sanchez

Solar-thermal collectors (above) are only part of a SHW system. The balance of system components (left) and labor can be up 75% of the system cost. Together, these components make an RE system that is two to three times as efficient as a PV system.

A Simple SHW Payback Scenario

First, we'll look at a simple solar heating system payback. The installed cost of a two-collector direct forced-circulation antifreeze system with an 80-gallon tank is typically between $8,000 and $9,000. In Richmond, Virginia, this system will produce an estimated 3,100 KWH per year (equivalent to about 10.6 million Btu), according to the Solar Rating and Certification Corporation (SRCC). Richmond, with an average of 4.8 peak sun-hours per day, has a moderate climate and is near the U.S. average for payback times (see table). The SRCC publishes estimated production data for many other cities on their Web site (see Access).

Mild Climates

In Hawaii and the southern part of each state that borders Mexico or the Gulf, the climate is mild enough to allow lower-cost SHW systems. Integral collector storage (ICS), thermosyphon, and direct forced-circulation systems are also used in these climates. The installation cost of these systems can be thousands of dollars less than the example two-collector SHW system, dropping payback length by 10% to 30%.

Payback for Virginia SHW Systems

Cost Per KWH	Daily Cost Offset	Annual Cost Offset	Simple Payback (Years) System Cost = $9K	System Cost = $8K
$0.10	$0.85	$310	29	26
$0.15	$1.27	$465	25	17
$0.20	$1.70	$620	15	13
$0.25	$2.12	$775	12	10
$0.30	$2.55	$930	10	9

A Simple PV Payback Scenario

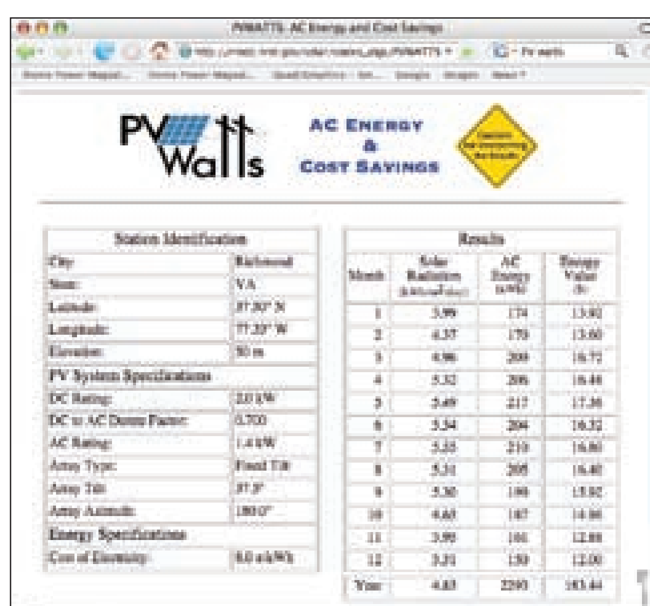
Now let's look at a simple PV payback scenario based on a 2 KW, batteryless grid-tied system. The estimated installed cost of this system is between $16,000 and $20,000 ($8 to $10 per watt). Calculating system KWH production is done slightly differently for PV systems than for SHW systems, but both methods arrive at the average expected KWH production. This example system is also located in Richmond, Virginia, again at 4.8 average peak sun-hours per day. Average peak sun-hour values account for cloudy days, so we can simply assume that 4.8 hours per day of full sun is received every day of the year. We also multiply by a 0.70 derating factor to account for inefficiencies due to temperature, inverting, module production tolerance, wiring losses, and module soiling. This system can produce an average of 6.72 KWH per day (2 KW x 4.8 sun-hours x 0.70 derating) and 2,453 KWH per year. Plugging this estimated output into different electricity costs gives us the info for the PV Payback table.

PV systems are great additions to any home with good solar access, but their efficiency is still well under 20%. Payback time on PV systems can be many years.

PVWatts Data Verification

To verify the estimated PV KWH energy production figures, we can use PVWatts, an online PV energy estimation program supplied by NREL (National Renewable Energy Lab, see Access).

Grid-direct inverters allow PV systems to be simpler, less expensive, and, therefore, more cost-effective than their battery-based counterparts—but PV systems still need significant cost decreases to catch up with the high efficiency of SHW systems.



Payback for Virginia PV Systems

Cost Per KWH	Daily Cost Offset	Annual Cost Offset	Simple Payback (Years) System Cost = $20K	Simple Payback (Years) System Cost = $16K
$0.10	$0.67	$245	82	65
$0.15	$1.01	$368	54	44
$0.20	$1.34	$491	41	33
$0.25	$1.68	$613	33	26
$0.30	$2.02	$736	27	22

This easy-to-use program allows us to select our site (Richmond, VA) and enter the 2 KW system size to calculate energy production data on a monthly and yearly basis. In this case, PVWatts estimates average AC energy production to be 2,532 KWH per year. Our estimation of 2,453 KWH per year is within 3% of the PVWatts estimation. You can use this calculator to find energy production values for other PV system sizes in other cities and states.

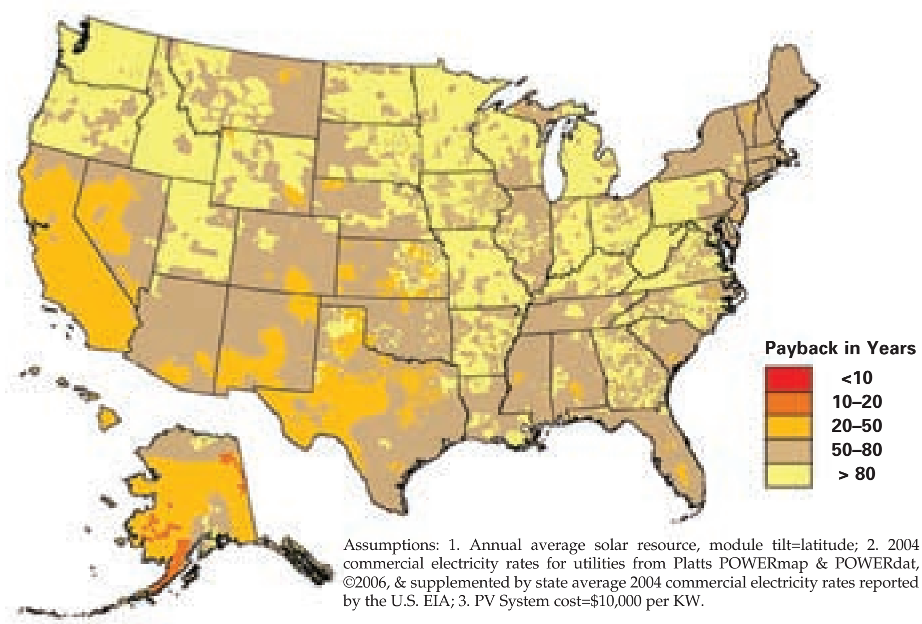
Payback Comparison

Looking at the solar payback tables, we can see that the sample solar hot water system's payback is about 2 1/2 times faster than our sample grid-tied PV system. Of course our estimations assume no available incentives, so actual payback times will depend heavily on available solar rebates and tax credits (see "Solar Assistance" sidebar). Also check out the incredibly fast payback times of the energy-efficiency upgrade example (in the "Efficiency Pays" sidebar), where we see full financial payback in months, rather than years.

NREL also has payback maps for SHW and PV systems. These maps illustrate how payback times vary for different locations across the United States. Although the NREL payback maps are a little outdated with 2004 data, they are still worth a look. The fine print states that the grid-tied PV systems have an installed cost of $10 per watt—a reasonable figure, but perhaps a little high. The SHW map assumes a cost of $900 per square meter (about 10 square feet) and 40% efficiency. This cost is too low for the pump-driven 80-gallon example system (according to NREL estimates, our $8,000 to $9,000 system would only cost $6,000). The rise in copper prices in the last four years is probably a factor in this discrepancy. Even with this cost difference, the maps are an eye-opener for how the two types of systems pay back their owners. What the maps don't show is the current trends of lower PV installation costs and higher SHW material prices—which are somewhat narrowing the previously wide gap in the respective payback times.

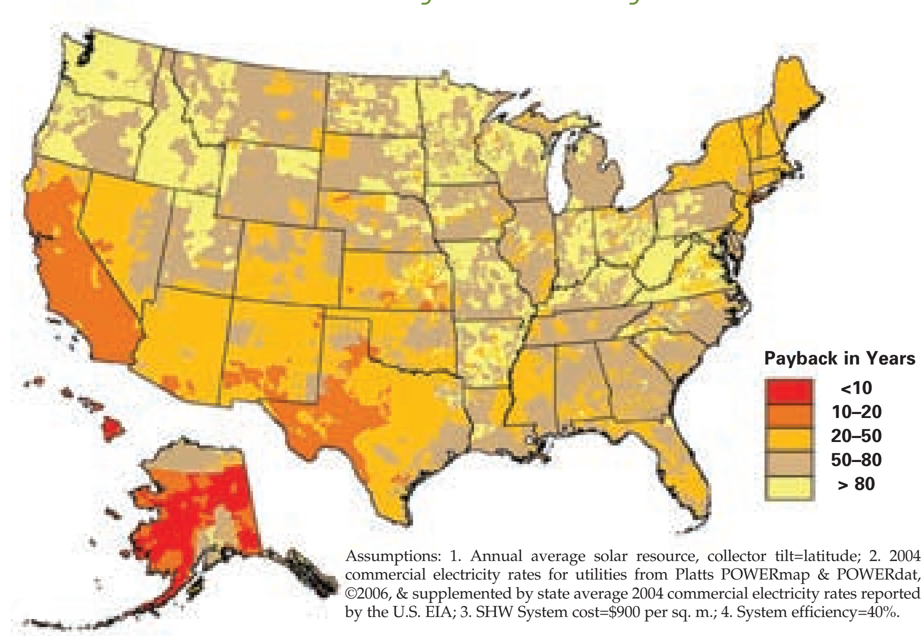
While these simple payback calculations are important to the pocketbook, the primary motivator for many is not which investments will yield the fastest payback, but rather how can they produce renewable, clean electricity or hot water.

Photovoltaic System Payback



Assumptions: 1. Annual average solar resource, module tilt=latitude; 2. 2004 commercial electricity rates for utilities from Platts POWERmap & POWERdat, ©2006, & supplemented by state average 2004 commercial electricity rates reported by the U.S. EIA; 3. PV System cost=$10,000 per KW.

Solar Hot Water System Payback



Assumptions: 1. Annual average solar resource, collector tilt=latitude; 2. 2004 commercial electricity rates for utilities from Platts POWERmap & POWERdat, ©2006, & supplemented by state average 2004 commercial electricity rates reported by the U.S. EIA; 3. SHW System cost=$900 per sq. m.; 4. System efficiency=40%.

Compared to PV systems, SHW systems produce more energy at a lower installed cost. But many people opt to install both types of systems to offset more of their total energy use.

Photo courtesy www.sunearthinc.com

"...these (solar) examples substantially reduce greenhouse gas emissions and air pollutants WHILE they are paying back the up-front cost..."

Efficiency Pays

It is worthwhile to look at the payback times for simple energy efficiency-upgrades (negawatts), such as changing out incandescent lights for more energy-efficient compact fluorescent lights (CFLs). Ten 60 W incandescent light bulbs can be replaced with ten 15 W CFL bulbs for $30 and still produce about the same amount of light. Each bulb saves 45 watt-hours (60 W – 15 W = 45 W) per hour of operation. Assuming an average operating time of 5 hours per day, the energy savings for all ten bulbs is 2,250 watt-hours or 2.25 KWH per day (450 W x 5 hrs. per day)—about 821 KWH per year. These bulbs will last about 10,000 hours (about 5 1/2 years), compared to the 30 years of example solar systems, but the ROI shown is 4.3 *months* at the most.

Payback for the Ten $3 CFLs

Cost Per KWH	Daily Cost Offset	Monthly Cost Offset	Payback (Months)
$0.10	$0.23	$7	4.3
$0.15	$0.34	$10	3.0
$0.20	$0.45	$14	2.1
$0.25	$0.56	$17	1.8
$0.30	$0.68	$21	1.4

Solar Assistance

These financial payback scenarios are calculated without including any financial incentives, but tax credits are available from the federal government until the end of the year. Many U.S. states, regions, and utilities also offer substantial rebates, tax credits, tax exemptions, loans, and other economic incentives for solar-electric and solar hot water systems.

Each state offers different incentive programs. For example, Connecticut offers a rebate for small residential PV systems of $5 per watt for the first 5 KW and $4.30 per watt thereafter. So a 2 KW system installed in Connecticut would have a lower cost of $6,000 to $10,000 (rather than $16,000 to $20,000), not including federal incentives or tax exemptions. The federal tax credit would reduce this cost by an additional $2,000 for qualified taxpayers.

In some locations, the residential tax credit is equal for PV and SHW, but in most cases, PV systems have more generous incentives. Hawaii favors solar hot water systems with a recent law that mandates SHW systems on all new homes built after January 1, 2010. For more information about incentive programs, visit the Database of State Incentives for Renewables & Efficiency (www.dsireusa.org).

The reduction of pollutants such as carbon dioxide (CO_2), sulfur dioxide (SO_2) and nitrogen oxides (NOx), as a result of replacing "average" U.S. utility energy—which includes hydroelectricity, nuclear, oil- and coal-based generation—with renewables or efficiency measures is shown in the "Pollutant Savings" table. Note that emissions from strictly coal-based electricity, which accounts for about 50% of all electricity generation in the United States, will be higher.

All these examples substantially reduce greenhouse gas emissions and air pollutants *while* they are paying back the up-front cost—and will continue to produce pollution-free energy (or reduce pollutants, in the case of the energy-efficiency upgrade) *after* they have achieved financial payback.

Annual Pollutant Savings

Type	Energy (KWH)	Cost	CO_2 Savings (Lbs.)	SO_2 Savings (Lbs.)	NO_x Savings (Lbs.)
SHW (80 gal.)	3,100	$8K–-$9K	4,340	25	16
PV (2 KW)	2,453	$16K–-$20K	3,434	20	12
CFLs (10 bulbs)	821	$30	1,149	7	4

Leveling the Playing Field

No matter how you feel about solar incentives, it is important to realize that all power production is subsidized. Conventional (coal, oil, natural gas, and nuclear) power production is subsidized in many ways, including direct financial support (grants, low-interest loans, R&D), preferential tax treatment (tax credits, exemptions on royalties, accelerated depreciation), trade restrictions (quotas, trade embargoes), and liability limits (for nuclear energy). According to the *World Energy Assessment Overview—2004 Update*, annual worldwide subsidies for conventional energy averaged $250 billion, without considering military costs. Subsidies for renewable energy were about 4% of that—about $10 billion combined for the United States and Europe in 2004. It is through these subsidies that conventional power rates are kept artificially low.

Since we did not include any incentive programs in our simple payback scenario, a true economic comparison between renewable and conventional energy could only be established if subsidies for conventional power were also removed. If were we also able to quantify other externalities to conventional power—such as its environmental impact (climate change; water, soil, and air pollution), impacts to public health, and military requirements to protect the fuel supply and nuclear power plants (and waste storage)—and include this in our comparison, we would get much closer to comparing "apples to apples."

Because it is unlikely that subsidies for conventional power production will be removed or environmental externalities will be incorporated in the dollars per KWH for conventional energy, offering financial incentives (e.g., rebates, tax credits, tax exemptions) and other subsidies—such as government funds for renewable energy R&D—to renewable energy consumers and producers helps level the playing field between conventional and renewable energy (see "Power Politics," this issue).

Utility Energy Rates & Payback Time

While many utilities sell electricity at affordable rates, inflation as well as energy price history and forecasts indicate price increases in our future, which will make RE systems' payback even quicker. Historical data reported by the Edison Electric Institute shows that from 1929 to 2005, the average annual price increase for electricity has been 2.94% per year. And according to the Energy Information Administration June 2008 *Short Term Energy Outlook*, utility rates are projected to increase by an average of 3.7% in 2008 and by another 3.6% in 2009.

Note also that we are figuring payback times on utility rates based on conventional energy production, which does not account for "externalities." If consumers had to pay for the true price of conventional energy (coal, natural gas, fuel oil, and nuclear) without the benefit of hidden subsidies and unaccounted-for environmental and military costs (see "Leveling the Playing Field" sidebar), payback times for solar would decrease dramatically.

Access

Solar Thermal Editor **Chuck Marken** (chuck.marken@homepower.com) is a New Mexico-licensed plumber, electrician, and heating and air conditioning contractor. He has been installing and servicing solar thermal systems since 1979. Chuck is a part-time instructor for Solar Energy International and the University of New Mexico.

Justine Sanchez (justine.sanchez@homepower.com) is a NABCEP-certified PV installer, *Home Power* technical editor, and Solar Energy International instructor. Justine lives, works, and teaches from an on-grid PV-powered home in Paonia, Colorado. And while her PV system will not reach the financial payback milestone for another 44 years (at the local utility rate of $0.09 per KWH), she couldn't care less—it has negated 8,769 pounds of CO_2 in its 24 months of operation.

SRCC • www.solar-rating.org

NREL's PVWatts • http://rredc.nrel.gov/solar/codes_algs/PVWATTS/

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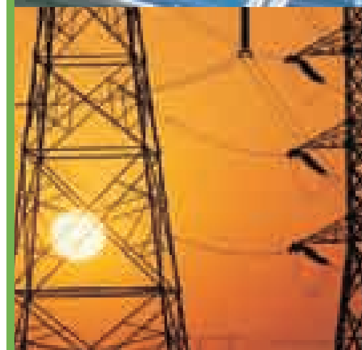


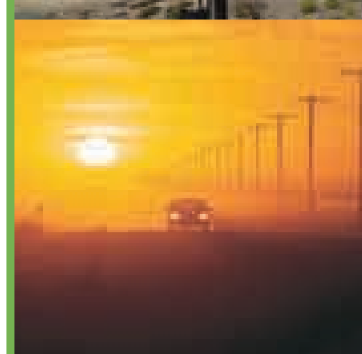
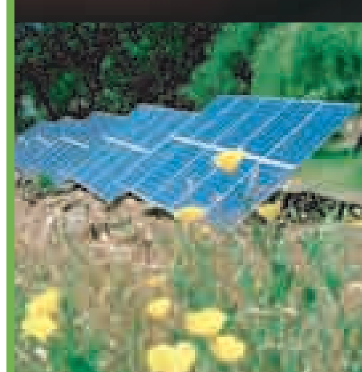

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Choosing *Your* RE Installer

Finding the right renewable energy installer can make the difference between a satisfying experience and a nightmare. In a growing industry, new companies are popping up on a regular basis, and it's not always easy to know which installers are adequately qualified.

by Laurie Guevara-Stone & Ian Woofenden

Installers Eric Hansen and Bob-O Schultze of Electron Connection, doing the heavy lifting for a solar carport.

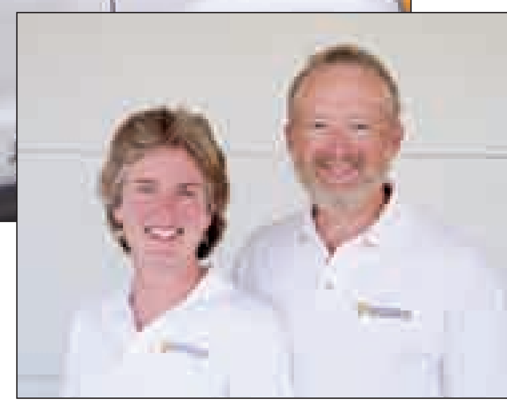
www.shawnschreiner.com

Mail-order companies, large discount warehouses, small mom-and-pop businesses, and large corporations all sell and/or install renewable energy (RE) systems. As the number of dealers, distributors, and installers grows, being an informed consumer is increasingly important. It will save you money, time, and aggravation to do advance research to find an installer who best meets your needs. You'll want to be sure that the person designing and installing your new system has the expertise to make it efficient, safe, and reliable.

Geoff Greenfield, an installer with Third Sun Solar and Wind Power of Athens, Ohio, advises people to verify an installer's experience before hiring them. While everyone has to learn somewhere, if you want to hire a novice, make sure you are willing to risk being part of their learning curve. New installers should learn by working with experienced industry professionals—not by trial and error on your system.

Greenfield also suggests that you take a close look at your prospective installer's approach and attitude. "Select someone who will listen to and serve *your* true goals and motivation," he says. "Too often a client will end up with a one-size-fits-all solution that isn't what they really wanted. If your installer's only solution is a hammer, everything starts to look like a nail."

Experience pays off in the end. The pain of a poorly designed or installed system lasts much longer than the short-term sting of paying a bit more. You can, however, choose to save money by



Anne and Randy Brooks are the principals behind Brooks Solar of Chelan, Washington.

working with the installer on parts of the project. Why pay an installer's wages to dig that trench, or pour that cement? If your installer is agreeable, it may save some money to do it yourself.

"If you want to assist in the installation," says solar consultant Joel Davidson, "be sure the installer understands what you want to do. Some technicians will not work with homeowners because of the hindrance factor or insurance liability; others won't because their own lack of skill and experience will become obvious."

Veteran installer Dave Palumbo of Vermont-based Independent Power says, "One thing I tell do-it-yourselfers is that this stuff is not easy. It may look slick when you see a completed system, but there are 101 ways to mess it up along the way." Palumbo has seen customers balk at his prices, only to later realize that it was a bargain to have the job done right the first time rather than labor over the details themselves or deal with an inexperienced installer.

Choose Wisely

Most of us want the best product for the least cost. But shopping by price alone can get you in trouble in the long run. What you're trying to buy is renewable energy for *years.* That means that you want reliable equipment installed for the long haul. Here's a listing of some key issues to consider when selecting an installer.

Professional Credentials. Organizations are now certifying installers by a set of standards, and seeing an installer's credentials can give you an idea of their qualifications. The North American Board of Certified Energy Practitioners (NABCEP) offers solar-electric and solar-thermal certification, and they are working on a wind certificate—all fairly rigorous certifications that involve not only difficult written tests but also require field experience. That said, many seasoned pros with excellent qualifications don't see the need for additional certification. They may choose to not dedicate the extra time or expense to become NABCEP certified.

North American Board of Certified Energy Practitioners
CERTIFIED Solar PV Installer ®
John Doe #031027-45

Competence will always be as important as credentials, and always harder to judge. Randy Brooks of Brooks Solar in Washington State recommends that prospective system owners trust their instincts. Ask yourself if potential installers look and sound like they know what they are doing, he says. Interviewing more than one prospect and comparing their responses will help you feel more confident about your judgment through understanding your own needs and learning what to appreciate in an installer.

Electrical License. If you contract with an installer who doesn't have an electrical license, you or your installer may need to hire a licensed electrician to obtain the permit, supervise the job, and do the final AC hookup. Regulations for residential electrical work vary from state to state, so be sure to check with your local code officials prior to installation. Your installer should have a good working relationship with the local electrical inspector. Also, if you expect to take advantage of financial incentives, be aware that many states won't provide rebates to unlicensed or unapproved installers.

"The pain of a poorly designed or installed system lasts much longer than the short-term sting of paying a bit more."

Dave Palumbo of Independent Power designs and installs RE systems in northern Vermont.

Bonded & Insured. Make sure your installer has liability insurance to protect you against installation mishaps—a ladder that accidentally shatters a picture window, for instance. You need to be protected if the installer's work damages your house during or after the installation, or if one of the company's workers is injured on the job. Some installers advertise that they are "bonded" as well. This guarantees that the contractor will meet their obligations in a satisfactory manner. Failure to do so results in the bonding company paying you compensation. However, being bonded is expensive, so if you want an installer who is both bonded and insured, you'll probably have to forego a one-person operation for a larger installation company.

Training. How recently and where has your installer been educated and trained? Find out if the installer has kept up-to-date with training courses on the specific products they sell. Many companies that manufacture and distribute RE products offer training, enabling installers to stay current on new product developments and how they fit into RE systems.

Experience. Don't be shy about asking about an installer's experience. Every installation is different, so the more installations an installer has handled, the more likely yours will be manageable for them. Find out how many systems similar to yours the installer has designed and installed. Plus, there are always new products entering the market, and new regulations to deal with. An installer who has completed several recent installations will probably be familiar with the newest products and the latest code issues.

Variety & Quality of Products. The variety of products an installer carries may or may not be important to you. But the more brands an installer carries, the more likely they will have one that fits your application. However, if the installer only carries a couple of brands and those brands work for your system, variety is not important. While the variety of products might not be crucial, the quality always is.

Research the components that your installer suggests. Do the electrical products meet industry standards? All components used in your system should be listed by Underwriters Laboratories (UL) or an equivalent testing agency. UL is a nonprofit product testing and certification organization that verifies electrical products are safe for their intended use. ETL Semko and the Canadian Standards Association (CSA) provide similar acceptable approvals. Checking products to make sure they are UL-, ETL-, or CSA-approved is one way to make sure the equipment used for your installation is reliable and safe.

What kinds of warranties come with the products that your installer carries? Also, how long have the equipment manufacturers been in the industry? Warranties are meaningless if the manufacturers aren't around in a few years. If you know of other people who have used these products, ask for their feedback: Are they satisfied? Have they had problems?

Service Agreements & Performance Guarantees. Installers may provide you with some kind of optional service agreement. If problems arise with your system, what services will the installer provide and for how long? Will the installer be readily available to troubleshoot and fix problems? If something goes wrong, who is responsible for repair or

"Competence will always be as important as credentials, and always harder to judge."

replacement costs? Who is responsible for maintaining the system? If you are responsible, what kind of training will the installer provide? Will basic system safety issues be explained? Although service or maintenance agreements have not been standardized throughout the industry, many installers will agree to a site visit at least once a year to make sure the system is performing satisfactorily. For the early years of a system's operation, consider buying a service contract.

References. Ask for and contact an installer's former clients to find out if the installer was knowledgeable, easy to work with, and took the time to explain the system's operation. Also find out if their systems are working well, if there have been any problems, and, if so, how the installer handled them. Ask for an installer's business references, and check them, especially if the company's reputation is unknown.

"Asking for references is good," says installer Kelly Keilwitz of Whidbey Sun & Wind in Coupeville, Washington, "but keep in mind that the contractor will use their most-satisfied customers as references. It may be possible, with a little sleuthing, to find and approach other past customers, not specifically recommended by the contractor. This may give you a more balanced picture of the contractor's suitability for your project."

Energy Efficiency. Ask about how to maximize the benefits of your system through energy efficiency and conservation. Installers willing to take this extra step of reducing demand can be worth their weight in gold. Many otherwise competent installers get in, install, and get out without ever touching on this important subject. For every dollar spent on efficient lighting and appliances, $3 to $5 can be saved on the RE system used to power them.

Questions to Ask Potential RE Installers

All Technologies

- ❑ Do you live with renewable energy systems yourself?
- ❑ What is your motivation for working in this industry?
- ❑ How did you learn your trade?
- ❑ How many years have you been in business and how many systems have you installed?
- ❑ Are you licensed, bonded, and insured, and do you hold certifications?
- ❑ What certifications do your installers hold, and what ongoing training do they receive?
- ❑ Do you offer warranty support and service contracts?
- ❑ Can you provide me with business and customer references in my area?
- ❑ What sort of lead time will there be from the time I write the check until the time my system is producing renewable energy?
- ❑ Do you include energy-efficiency and conservation techniques in your site analysis to make sure I get the most out of my RE system?

Renewable Electricity

- ❑ Do you have experience with both battery-based and batteryless systems, and on-grid and off-grid systems?
- ❑ What different module, turbine, and inverter choices do you offer?
- ❑ Do you give an accurate estimate of system production with your quotes?

Wind Electricity

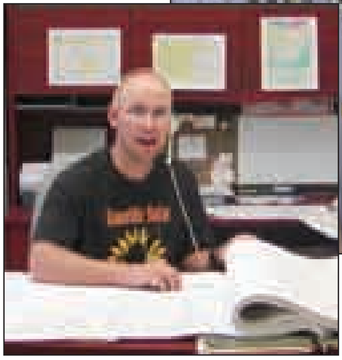
- ❑ Do you install tilt-up and fixed towers?
- ❑ What are the tallest and shortest towers you've installed?
- ❑ How do you perform a wind site/resource assessment?
- ❑ What turbines have you installed, and what's your track record for reliability and production?

Hydro Electricity

- ❑ How will you measure head and flow?
- ❑ Do you work with high-head and low-head systems?
- ❑ What sorts of intakes do you install and how have they worked?
- ❑ How do you protect the flora and fauna in the streams you work on?

Solar Hot Water

- ❑ What types of SHW systems do you install, and what are your preferences?
- ❑ Do you use flat-plate collectors, evacuated tubes, or both? Why?
- ❑ How do you estimate and measure performance of the systems you install?



Geoff Greenfield, of Third Sun Solar and Wind Power, leads a full-service RE company in the Midwest.

Think Locally

To locate an installer near you, inquire with your local RE organizations. The American Solar Energy Society (ASES) has chapters in 34 states, and your local chapter can provide you with a list of installers and dealers (see Access), as can other local organizations that deal with RE. ASES also cosponsors the "Find Solar" Web site at www.findsolar.com, where you can find detailed listings of RE dealers across the United States and Canada. If you live in the Heartland, the Midwest Renewable Energy Association offers a great resource for finding an installer. NABCEP also has a listing of certified installers on their Web site.

You can also check out *Home Power's* Web site for a searchable database of RE dealers and installers, or look in the Installers Directory at the back of each issue. Local installers provide an on-the-ground perspective that online and mail-order suppliers can't achieve, and will perform comprehensive, on-site solar and load analysis that helps them recommend the most appropriate equipment. In most cases, a face-to-face two-way interview is key to executing a thoughtfully designed and well-planned installation.

"Local installers provide an on-the-ground perspective that online and mail-order suppliers can't achieve."

The Final Call

When you're ready to select an RE installer, we recommend that you ask lots of questions (see the "Questions" sidebar). The answers should add up to a reasonable profile of the person you're interviewing. But this is not a multiple choice test, and in the end, you'll need to go with your gut and select an installer that is a good fit for you.

Don't underestimate the importance of finding someone you "click" with. When recommending installers locally, we try not to match a conservative-minded installer with a dreamy tree-hugging client, or a backwoods hippie installer with a yuppie client. While your system is a machine, your installer is not. We're talking about people, and compatibility matters—so while the installer sizes up the site and the system design, you should size up the installer.

Access

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Ian Woofenden (ian.woofenden@homepower.com), *Home Power* Senior Editor, educates current and potential renewable energy installers via articles, consulting, and workshops.

Installer Listings:

American Solar Energy Society • 303-443-3130 • www.ases.org

Find Solar • www.findsolar.com

Home Power Business Directory • www.homepower.com

Midwest Renewable Energy Association • 715-592-6595 • www.the-mrea.org

NABCEP • 518-899-8186 • www.nabcep.org


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Bringing Sustainability Home

by Don Joslin

Photos courtesy Don Joslin, Architectural & Environmental Associates

Thirteen miles from Flagstaff, nestled in the northern Arizona mountains, Carl Ramsey's award-winning home sets a high bar for building efficiency and approaching energy sustainability.

Carl Ramsey's home is conventional in only one respect—its aesthetics. His one-story house, with plank siding and a standing-seam metal roof, blends tastefully with other homes in the area. But that's where the similarities end. The home performs head-and-shoulders above the rest, having earned a platinum rating from the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program.

The home's success relies on blending time-tested strategies, such as passive solar design and rainwater harvesting, with modern, high-tech systems. A grid-tied PV system and wind turbine provide electricity. Solar hot water collectors supply domestic hot water and heat for the radiant floors. Biological and environmental solutions include ultraviolet water purification, a greywater system, and an automated indoor air-quality system. Add environmentally friendly materials and finishes, and you get a comfortable, healthy, beautiful, and efficient home that is net-zero energy, net-zero carbon, and net-zero water.

Building Design & Efficiency

Carl, an architect specializing in energy-efficient design, wanted a home that would provide its own potable and irrigation water and its own energy, all with minimal environmental impact. Since the goals of the project fit so closely with the LEED guidelines, Carl registered the project in a pilot program: LEED for Homes. To earn the platinum certification, the construction materials and methods had to minimize the home's environmental impact, plus meet stringent energy performance levels (see "Scoring Sustainability" sidebar).

PASSIVE HEATING. The house was designed with a very long east-west axis to maximize exposure to the south. During the winter months, south-facing windows admit solar gain. A concrete block wall that traverses the center of the home along the east-west axis stores the solar heat. Additional thermal mass is provided by the 1 1/2-inch concrete radiant floor. During the summer, when the sun is high in the sky, roof

Features of this home include grid-tied PV- and wind-electric systems, solar hot water, and passive solar design.

overhangs shade the south-facing glass to minimize solar gain. Mass and windows were optimally sized using Energy-10 modeling software (see "A Model Home" sidebar).

PASSIVE COOLING. One of the home's features is a specially designed dormer and clerestory in the middle of the roof that functions as a passive "cooling tower." The opening of those windows is computer-automated. When a sensor measures a certain temperature, the windows open to exhaust warm air, creating a natural convection current that draws cooler air into the home through windows at lower levels.

EFFICIENT CONSTRUCTION. Exterior walls were constructed of 8-inch-thick structural insulated panels (SIPs), made with expanded polystyrene foam sandwiched between 1/2-inch-thick oriented strand board (OSB), providing R-36 insulation. SIPs offer superior insulation and little air infiltration, allowing more precise control of the interior environment.

With good structural strength, the panels eliminated the need for additional framing, and still met local building codes. SIPs also generate less waste from trimming and reduce labor costs, while more easily staying within building tolerances by requiring fewer pieces to construct a wall. OSB is made of wood chips from renewable forests, and the small pieces of wood make use of more of the tree than does the milling of studs.

For non-bearing walls, headers were eliminated. Bearing walls use headers individually sized for specific locations,

A Model Home

Energy modeling software can help designers and homeowners predict a building's energy performance early in the design process, and offers a way to analyze materials or design options prior to committing to a direction. It also helps identify the most cost-effective, energy-saving measures *before* building.

Energy-10 software was used to analyze the Ramsey home design and suggest revisions (see Access). For instance, although LEED standards require that Energy Star-rated low-e windows be used throughout a structure, Energy-10 demonstrated that traditional clear glazing, instead of low-e coated windows, on the south side of the home would maximize passive solar gain. Modeling also helped achieve a proper balance between energy loss, solar gain, and thermal mass to avoid overheating the house.

REM/Rate, a sophisticated residential energy analysis, code compliance, and rating software, was used for assigning residential Energy Star ratings. Using local climate data, the software calculates heating, cooling, hot water, lighting, and appliance loads, and projects a home's energy consumption and costs. The REM/Rate analysis indicated that the Ramsey home exceeded the applicable Energy Star requirements by 70%.

Scoring Sustainability

In 2006, the U.S. Green Building Council established the Leadership in Energy and Environmental Design (LEED) to drive the home building market toward more sustainable practices and establish a national baseline for green building standards. Residences participating in the LEED for Homes certification program are awarded points which, when added up, determine a home's certification level.

- Innovation & Design Process (11 points possible): Points are awarded for the integrated, cost-effective adoption of green design and construction strategies, and for a high-performance building enclosure attained through appropriate design, materials section, and construction practices. Additional points are given for incorporating innovations or regional design strategies that minimize the home's environmental impact.
- Location & Linkages (10 points): Measures the home's location with respect to the larger community. Includes points for avoiding development in environmentally sensitive areas; and for building near or within existing communities, and near utility and transportation infrastructure.
- Sustainable Sites (22 points): Awards points for erosion control measures, xeriscaping and landscaping with native plants, surface water runoff control, and nontoxic pest-control measures.
- Water Efficiency (15 points): Addresses water conservation measures through water reuse (rainwater and greywater collection systems), water-efficient irrigation systems, and use of water-efficient fixtures and appliances.
- Energy & Atmosphere (38 points): Examines the home's overall energy performance relative to Energy Star-rated homes. Includes points for increasing insulation, implementing effective air-infiltration control strategies, maximizing window performance, reducing mechanical heating and cooling, incorporating daylighting, and using renewable energy generation.
- Materials & Resources (16 points): Points are awarded for using efficient framing techniques, sustainably harvested wood, and no- or low-VOC paints and adhesives. Reducing waste generation to below industry norms earns points.
- Indoor Environmental Quality (21 points): Points are given for minimizing the combustion gas leakage within a home, moisture-control measures, and effective ventilation and filtration strategies.
- Awareness & Education (3 points): Aims to maintain the performance of the home by educating the homeowner, tenant, and/or building manager about the operation and maintenance of the home.

— Chris Watson, LEED-AP (www.aeapower.com)

instead of the traditional 2 by 10s. Interior framing uses a 24-inch stud spacing instead of the 16- or 12-inch spacing. Studs line up with bearing points at walls, floors, and ceilings, decreasing the need for additional framing at structural points. Finally, all the walls use only one top plate instead of the traditional two-plate system. Instead, small metal plates connect the top plate to the studs. Drywall clips hold the wallboard in place and reduce the framing corners from the traditional three studs to just two.

SMART LIGHTS. A daylighting plan with well-placed windows and a clerestory ensures that the home is flooded with natural light. SolaTube insulated, concentrating skylights are placed strategically throughout the home. These fixtures redirect natural light through a reflective insulated shaft into the residence. Lighting fixtures are all Energy Star-rated and use compact fluorescent bulbs.

The house features high-performance, low-e coated windows to reflect, or absorb, solar energy, and to reflect UV light. The exception is the south-facing windows, which use traditional glazing to maximize solar gain.

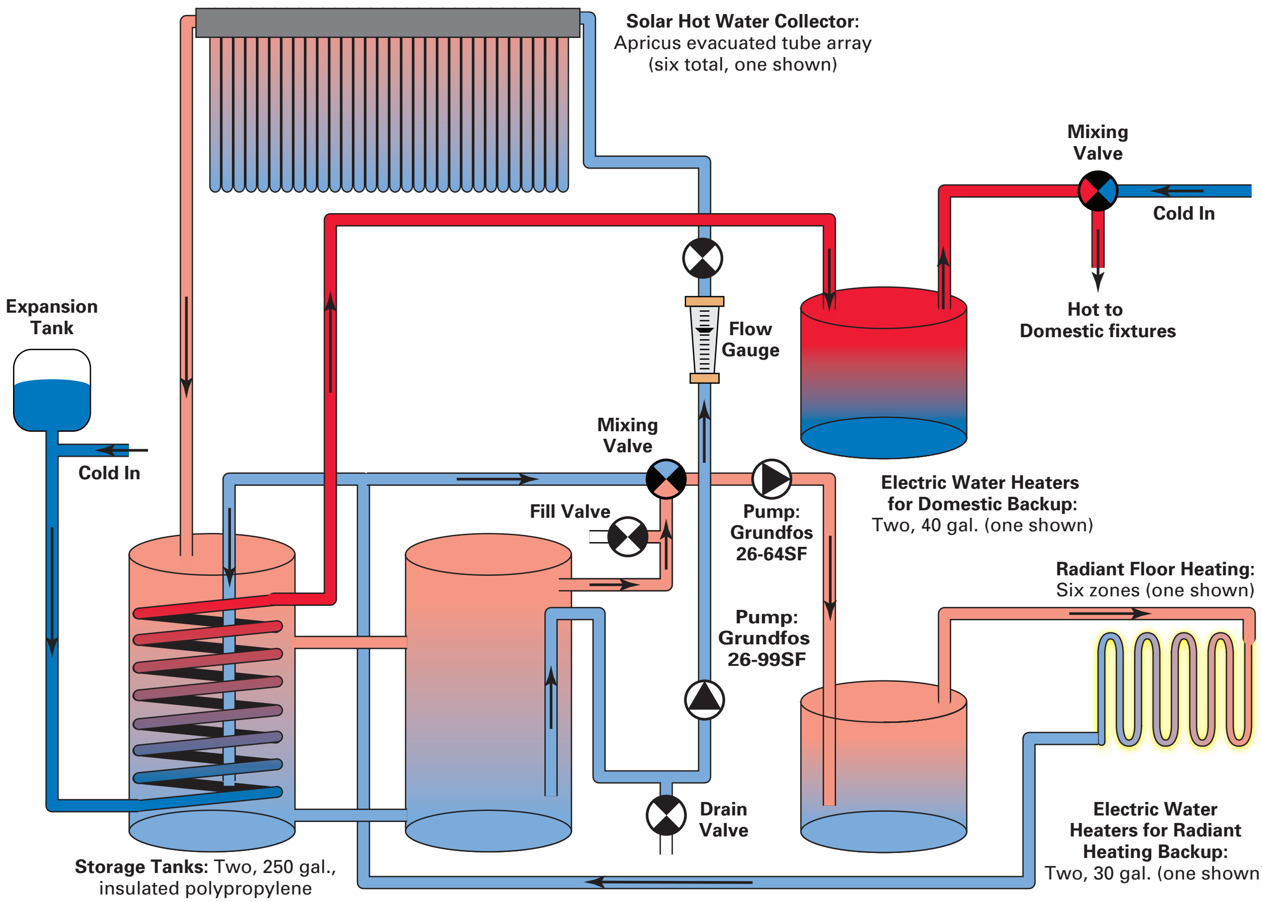
AUTOMATED AIR QUALITY. In most homes, exterior air infiltrates through tiny holes and cracks in the building envelope, allowing uncontrolled air exchanges (stale air out and fresh air in). But the Ramsey home is very tightly sealed—so tight that measurable natural air exchanges cannot occur. Instead, an automated heat recovery ventilator (HRV) with a high-efficiency particulate air (HEPA) filter provides fresh air to the interior. An exchange manifold captures most of the warmth or "coolth" prior to exhausting the stale air, and transfers it to the incoming air. The HEPA filtration system traps dust, pollen, mold, bacteria, and vapors to prevent them from entering with the fresh air. The HRV system exchanges three whole-house volumes of air every 24 hours, while minimizing heating and cooling energy losses.

A steam-electrode humidifier maintains interior humidity levels at 40%—considered optimum for a dwelling. The home's automated management system adjusts the humidity, temperature, and airflow to keep the interior of the home comfortable.

LEED Home Certifications

Level	Points
Certified	45–59
Silver	60–74
Gold	75–89
Platinum	90–136
Max. Available Points	136

Ramsey Drainback SHW System



SHW/Radiant Floor System Tech Specs

Overview

System type: Custom-designed drainback solar hot water/ radiant heat

Production: 5.92 million Btu per month average

Climate: High desert (7,000 ft. elevation; -2°F design temperature)

Domestic hot water produced annually: 95% of DHW; 75% of total heating & DHW load

Solar Equipment

Collectors: Six Apricus AP-30

Collector installation: Roof-mounted, south-facing, parallel to the roof (approx. 45° tilt)

Heat transfer fluid: Distilled water

Circulation pump: Grundfos 26-99SF

Pump controller: Resol DeltaSol Pro

Storage

Tanks: Two 250-gal. insulated polypropylene tanks, 200 gal. water level

Heat exchanger: Custom site-built, 180 ft., 3/4-in. coiled copper

Backup DHW: Two 40-gal., electric water heaters

System Performance Metering

Thermometer: Digital, built into solar controller

Flow meter: Pentair LDF239B flow meter

Radiant Floor System

Tubing: Rehau cross-linked PEX

Amount of tubing: 2,900 ft.

Number of zones: 6

Circulation pump: Grundfos 26-64SF

Pump Controller: Wirsbo

Tempering valve: Honeywell AM101R-UT, set to 110°F

Backup Radiant Heat: Two 30-gal. electric water heaters

ECO-FRIENDLIER PRODUCTS. Environmentally friendly interior finishes include earthen plaster finishes applied directly over drywall, OSB, and other interior building materials. Renewable-cork floors, clay-painted ceilings, and concrete countertops infused with recycled glass aggregate and fly ash (waste ash from power plants) augment the list of eco-friendlier materials. Locally harvested and milled beetle-killed ponderosa pine was used for the wood cabinets and base, window, and door trim.

MATERIAL SAVINGS. Through material reuse and recycling, the Ramsey home's construction waste was reduced to about 0.4 pounds per square foot, or 1,000 pounds total. A similarly sized but conventionally built home generates more than 12 times this amount—an average of 5 pounds of waste per square foot of building. Waste wood and gypsum board were ground and used as soil amendments, and leftover concrete and block were ground and used on the gravel road and as a paving base. Metal, cardboard, and paper scraps were recycled.

Renewable Energy

SOLAR ELECTRICITY. A 7.2-KW, grid-tied PV system provides the home's primary electricity. The building-integrated system also functions as a carport and was awarded additional LEED points for shading "hardscapes" (primarily patios, driveways, and other paved-over areas).

Electricity use for the home was estimated to be about 39 KWH per day, including four electric water heaters that serve as backup for the solar domestic hot water and the solar radiant floor heat (two for each application). The PV system was designed to provide about 79% of the total loads, averaging 31 KWH per day.

WIND ELECTRICITY. A 1.8-KW Skystream 3.7 wind turbine adds energy, especially from August through early October when afternoon thundershowers roll in almost daily, appreciably reducing solar-production but bringing a fairly reliable wind resource. The grid-tied turbine, manufactured by Southwest Windpower, sits on a 33.5-foot tower in an open field approximately 200 feet from the home. This reduces noise at the residence and provides unobstructed access to the wind when available. At a 9 mph average wind speed, we are producing 170 AC KWH per month.

SUSTAINABLE SPACE & WATER HEATING. The drainback SHW system, using six Apricus evacuated-tube collectors, provides winter space heating and year-round domestic water heating. Distilled water is pumped between the roof-mounted collectors and the first of two 250-gallon, unpressurized, insulated polypropylene storage tanks in the home's mechanical room. The first storage tank houses the heat exchanger for DHW and also feeds heated water to the second tank through convection. Heated water is pumped out of this second tank via a temperature-controlled mixing valve, through two 30-gallon electric backup heaters, and into the radiant floor heating system.

After it has run through the floor, the cooled water returns to the first storage tank. A tee in this water line, just prior to the return inlet on the storage tank, supplies the cold-water side of the temperature-controlled mixing valve. The DHW system draws hot water from the first storage tank's heat exchanger. The cold water supply, at household pressure, is fed through the heat exchanger, through two backup electric water heaters and another tempering valve, and finally distributed to the household. Thermal pipe-runs are insulated with R-5 pipe insulation.

PV/Wind Tech Specs

Overview

System type: Grid-direct solar- and wind-electric

Location: Bellemont, Arizona

Solar resource: 5.95 average daily peak sun-hours

Average monthly PV system production: 937 AC KWH

Utility electricity offset by PV system: 79%

Wind resource: 9 mph average wind speed

Average monthly wind system production: 170 AC KWH

Utility electricity offset by wind system: 14%

PV System

Modules: 40 Sharp ND-180U1, 180 W STC, 35.9 Vmp, 44.8 Voc

Array: 7.2 KW STC total, 287.2 Vmp, 358.4 Voc; subarray #1: three strings of 8 modules, 4,320 W STC, 287.2 Vmp, 358.4 Voc; subarray #2: two strings of 8 modules, 2,880 W, 287.2 Vmp, 358.4 Voc

Array installation: ProSolar rails mounted on south-facing carport frame, 20° tilt

Inverter #1: Sunny Boy SB 4000US, 4 KW, 600 VDC maximum input, 250–480 VDC MPPT range, 240 VAC output

Inverter #2: Sunny Boy SB 3000US, 3 KW, 500 VDC maximum input, 200–400 VDC MPPT range, 240 VAC output

System performance metering: Two Itron Centron CL200 KWH meters

Wind System

Turbine: Southwest Windpower Skystream 3.7

Rotor diameter: 12 ft.

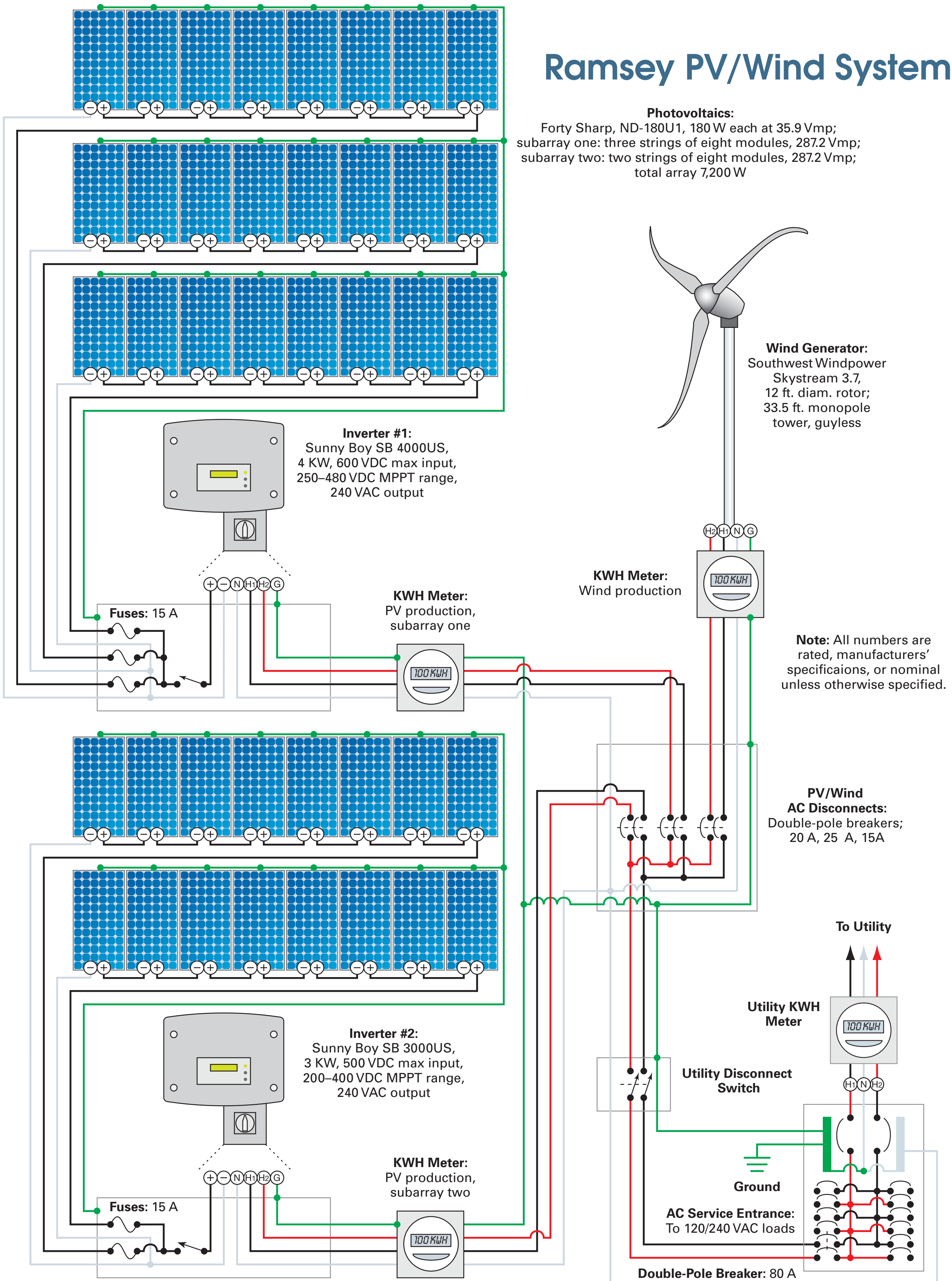
Rated energy output: 800 AC KWH per month at 21.2 mph (9.5 m/s)

Tower: Southwest Windpower, 33.5 ft., monopole (guyless)

Wind turbine controller/inverter: Integrated in turbine, 240 VAC grid-synchronous output

System performance metering: Itron Centron CL200 KWH meter

Ramsey PV/Wind System



The PV system includes two SMA Sunny Boy inverters, and a dedicated KWH production meter for each inverter.

Ramsey Home Incentives

Arizona Tax Credits	Amount
Greywater irrigation	$1,000
PV system	1,000
Solar hot water	75
Federal Tax Credits	
PV system	$2,000
Energy Star roof	500
Insulation	500
Electric water heater	300
Energy Star windows	200
Arizona Public Service Rebates	
PV system	$21,600
Solar hot water system	700
Total Incentives	**$27,875**

Water Independence

CATCHING RAIN. Without a well or connection to the municipal water supply, the home is completely water independent. A rainwater catchment system provides all of the home's water needs, both potable and for irrigation. Gutters on the house and outbuildings direct water into eleven 3,000- to 5,000-gallon polypropylene storage tanks with a total capacity of 37,000 gallons. Based on an average annual rainfall of 21.35 inches and the catchment area, the potential harvest is more than 120,000 gallons a year.

SAVING WATER. Water-efficient plumbing fixtures for showers, faucets, and toilets reduce water use to 70% below the national average without compromising comfort or convenience. A greywater system collects wastewater from the bathroom sinks, bathtub, shower, and clothes washer, providing water for irrigation. On the LEED assessment, the home achieved a perfect score in the water efficiency category.

Faucet aerators were sized at a flow rate of 0.375 gpm, and shower heads are 1.5 gpm. Two Caroma dual-flush toilets consume 0.6 gallons of water to dispose of liquid waste and 1.2 gallons of water for solid waste; and the third toilet uses 1.1 gallons of water per flush. An Energy Star LG Electronics horizontal-axis clothes washer and dryer combo adds to the water savings, and offers some energy savings compared to conventional units.

REDUCING RUNOFF & RECYCLING WATER. A series of berms and swales across the property's natural drainage paths help keep rainwater on site to reduce the need for supplemental irrigation. Native plants that are drought-tolerant and require minimal watering were used throughout. Supplemental watering comes from a drip-irrigation system fed by seven of the rainwater storage tanks and the greywater collection system. An automated control system monitors irrigation and shuts off the supplement if it senses rain.

RECLAIMING WASTE. The septic system provides complete treatment in a single precast concrete tank and relies on extended aeration, similar to that used in municipal wastewater treatment facilities. A UV light disinfects the effluent before releasing it to the leach field. Disinfection reduces the size requirements for the leach field and minimizes the possibility of contaminating groundwater.

The Costs of High Performance

According to Carl, "The extra cost for building 'green' can run from nothing to 5% or more, depending on amenities and methods. But the payback in reduced utility bills is considerable. At 2,720 square feet, the Ramsey home construction came in at $250 per square foot—very similar to typical custom homes in the region.

Part of the rainwater delivery system, and one of eleven catchment tanks.

The cost of building this high-performance home was offset somewhat by federal, state, and utility incentives available. Arizona is a particularly attractive state when it comes to solar-electric system incentives. The state allows a tax credit of 5%, capped at $1,000, which combines with the federal tax credit of 20%, capped at $2,000. Through its Solar Partners Program, Arizona Public Service (APS, the local utility) offers a rebate of $3 per rated DC watt, capped at 50% of the system cost for residential systems.

At building time, there were no wind rebates available from APS. This has since changed, and APS now offers a "solar and wind" rebate. After incentives, the power system cost was $38,000. Other tax credits and rebates for using greywater, energy-efficient design, and energy-efficient construction techniques amounted to $3,275.

Access

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Special thanks to Carl Ramsey, Jason Campbell, Chris Watson, Katy Johnson, Nathan Hodgson, and Radiance Heating and Plumbing for their assistance with this article.

U.S. Green Building Council • www.usgbc.org • LEED

Product Manufacturers:

Renewable Energy Systems:

Professional Solar Products • www.prosolar.com • PV mount

Sharp Solar • www.solar.sharpusa.com • PV modules

SMA America • www.sma-america.com • Inverters

Southwest Windpower • www.windenergy.com • Wind turbine

Green Materials & Finishes:

AFM Safecoat • www.afmsafecoat.com • Water-based door & trim stain/finish

American Clay • www.americanclay.com • Earthen plaster

Bricor Southwest • www.bricor.com • Low-flow faucets & fixtures

Capri Cork • www.capricork.com • Recycled rubber & cork flooring

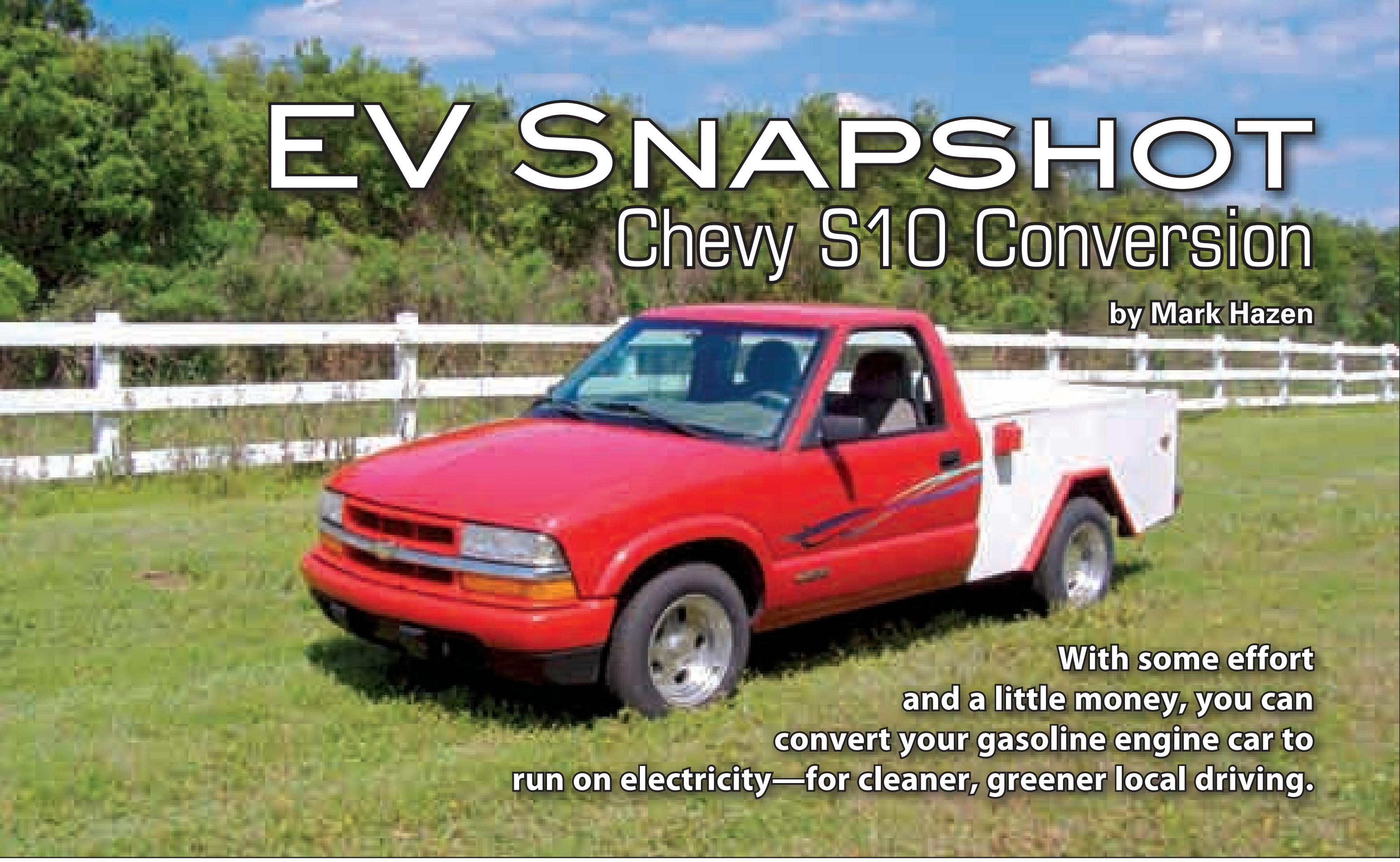
Coroma • www.caroma.com.au • Dual-flush toilets

CrystaLac • www.crystalac.com • Water-based cabinet stain/finish

Kohler • www.us.kohler.com • Plumbing fixtures

Marvin Co. • www.marvin.com • Windows

Sea Gull Lighting • www.seagulllighting.com • Light fixtures



EV Snapshot

Chevy S10 Conversion

by Mark Hazen

With some effort and a little money, you can convert your gasoline engine car to run on electricity—for cleaner, greener local driving.

I recently completed the conversion of my 1998 Chevy S10 pickup truck, taking about four months of evenings, weekends, and seven vacation days. There were setbacks and some skinned knuckles, but the effort was worth it. Here's a look at the process.

1. Engine Removed

The engine has been removed, and the compartment has been cleaned using degreaser. After cleaning, the frame was primed with a zinc primer and painted black. Note the motor mount bolted in place above the cross member, awaiting the motor.

2. Motor Mount

The motor mount was originally suspended between two rubber engine mounts. After the torque from the electric motor ripped the mounts, I replaced the rubber with metal tangs welded to the rubber mounts' bases. There is no reason to mount an EV motor on rubber, since there is no vibration. Mount your electric motor solidly.

3. Bed Removed

I removed the truck's original bed, sandblasted the frame, and primed and painted it. As you can see, it looks fresh from the factory. Notice the shackles that I added to the rear leaf springs to give the rear a little more height over the front end. Also notice the air shocks. This combination gives me the front-to-rear height balance that I wanted. As it turns out, the air shocks weren't needed. With only 16 batteries, weight is not an issue.

4. Batteries Installed

I purchased a small welding machine, a 14-inch cutoff saw, and an angle grinder to fabricate a secure battery rack, using 1 1/4- by 1/8-inch steel angle and some flat stock. The rack is securely bolted to the truck frame on each side and holds two rows of eight batteries.

Note the flat-stock strapping across the top of the rack between the batteries. These straps are bolted on with lock nuts. Holding the batteries securely in place is very important to prevent additional damage and injury in an accident.

Notice that the terminal lugs are connected to the terminals with wing nuts. To avoid terminal meltdown, I have since replaced the cable ends with terminal clamps for much better contact. The terminal tops and cable lugs had insufficient contact surface, and I melted three terminal posts before changing over to clamps.

The gray box on the right side of the battery rack is a makeshift fuse box that contains a 600-amp fuse. I drilled some holes for venting in the plastic electrical box. The fuse is an added safety measure in the event that the entire battery bank shorts out, say from a dropped tool or a traffic accident.

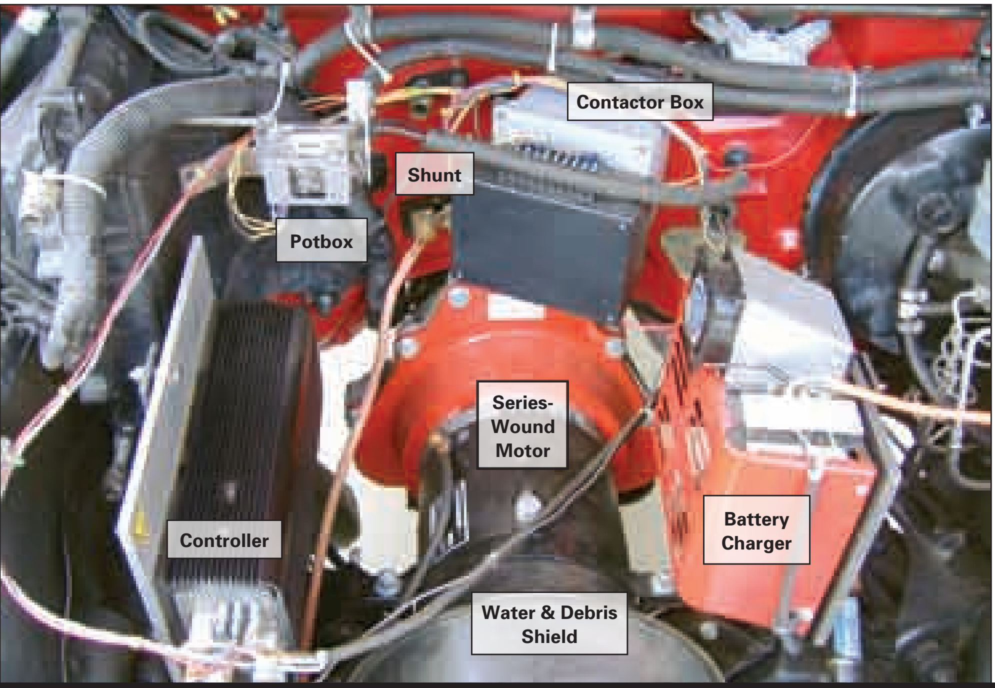
5. Finished Motor Compartment

First, notice the large bolt on the top of the motor—just above and to the right of the motor information plate. This bolt goes through a short metal tab that is welded to the top motor-mount strap. Together, this bolt and tab prevent the motor and transmission from twisting from the enormous motor torque.

This technique should only be used if you are using a professionally made motor mount that has been carefully sized for this bolt hole. The field coils for the motor are just below this hole, and clearances inside the motor are very small and precisely designed. A bolt that is too long can push the field coils into the spinning armature and damage the motor.

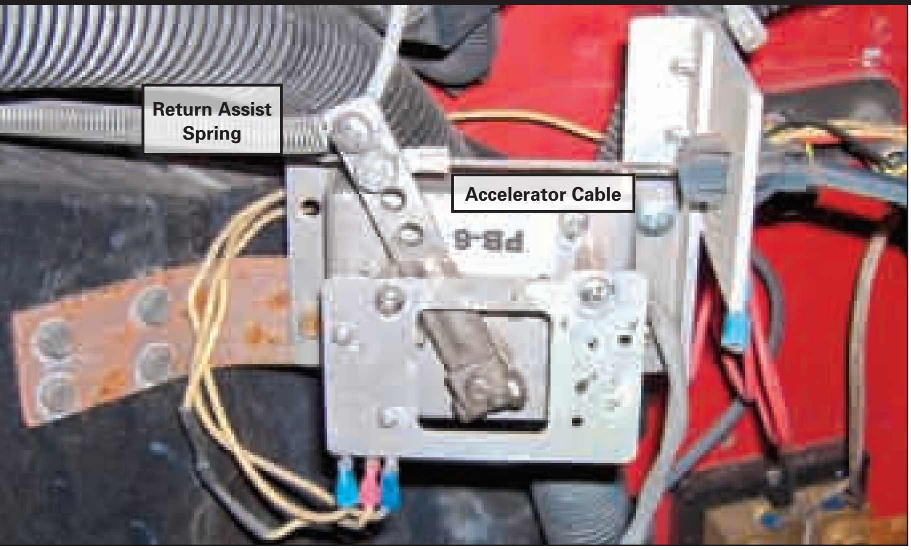
Front and center, you will see my old oil drain pan. It now serves to deflect rain that comes in the front of the vehicle and prevents it from getting into the motor brushes—without blocking airflow.

At the top left is the potbox, which is mechanically connected to the "gas" pedal via a flexible cable. The variable resistor tells the controller how much voltage to feed the motor. The controller sits to the left and above the motor, and is mounted on a 5/16-inch-thick aluminum plate. Both the motor and the controller run cool, barely above human body temperature.



To the right and above the motor is my homemade battery charger. I saved about $1,000 by designing and building the battery charger, as well as the 12-volt charger (not shown). The chargers and other electrical components are kept separate from the main battery bank as a safety measure in the event of a severe battery overcharge, which would release hydrogen gas and pose an explosion hazard.

The gray box (top center), mounted to the firewall, contains the heavy-duty contactor that passes the high current to the controller when it is energized.



6. Speed Control/ Potbox Installation

This photo shows how I installed the potbox made by Curtis. Installation was very simple. I added a piece of aluminum angle on the right with a larger flat piece screwed on to capture the accelerator cable sleeve. A piece of scrap iron flat stock was used to mount the control to the remaining plastic plenum for the air-conditioning evaporator. Note the added return assist spring that helps pull the control arm back and elevates the accelerator pedal. A crimp-on lug terminal was used to connect the accelerator cable to the control arm with a loose bolt and acorn nut.

7. Bed Framing

The original bed weighed 320 pounds. By building my own truck bed out of aluminum framing and ABS plastic sheathing, I shaved about 195 pounds off the truck's load and made a nice compartment for the batteries. Aluminum sheet can be used as well. Ninety-degree angle plates and angle brackets give the bed framework excellent rigidity. Self-drilling screws made attaching the framework easy.

The ABS sheathing, which was attached using countersunk stainless-steel #8 sheet-metal screws, can be painted with standard auto paint.

8. Finished

Here it is. The tail lights and side running lights are bright LED assemblies from the local auto parts store. I added fog lights to the rear, just under the bumper on each side, for backup lights. Because EVs operate so quietly, I placed a 12 V beeper under the rear bumper that activates when I set the transmission into reverse—a courtesy to warn pedestrians.

Access

Mark E. Hazen (mail@evhelp.com) is an electronics engineer and professional writer. He has written several college-level electronics engineering textbooks, a paperback on alternative energy, and numerous articles covering analog circuits and communications. He holds a patent on PWM motor control.

EV FAQs

Ever since I converted my Chevy S10 pickup truck into an electric vehicle, I've become a celebrity of sorts. My red truck with its custom-built, aluminum battery bed has been known to turn some heads. And the name of my Web site—www.evhelp.com—in big, bold red lettering across the tailgate is hard to miss. Admittedly, I'm not exactly shy about owning an EV. In fact, I love the attention, and I am thrilled to have people stop me and ask questions about it. It's my way of getting the word out about the practicality and reliability of these custom conversions.

How much did it cost?

Not counting the cost of the donor vehicle, expect to spend between $6,500 and $9,500. The actual amount depends on the type of vehicle you are converting, which partially determines the motor size, controller, and number of batteries. The total cost also depends on how much work you can do yourself. The total conversion cost me about $10,000—*including* the truck. That's not a lot of money when you consider that every vehicle has an initial purchase price, followed by cost of operation and cost of ownership. What results from this modest initial investment is very low operating and ownership costs.

How much does it cost to drive?

The cost per mile is calculated from the cost of electricity per kilowatt-hour, distance driven, and the number of KWH needed to recharge the batteries. I pay 9.6 cents per KWH of electricity, and it takes 11 KWH of energy to recharge the batteries after driving 20 miles. That puts my cost per mile at roughly 5.3 cents—a per-mile savings of nearly 11 cents over the original vehicle's performance. The original stock vehicle with an internal combustion engine used 1 gallon of gas to drive the same 20 miles. At $4.00 per gallon of gas, the cost comes to 20 cents per mile.

How far can you drive on a charge?

I have found that my truck, which has 16, 6-volt golf-cart batteries and weighs a total of 3,700 pounds, has a 35-mile maximum range and a 20-mile range if staying within a 50% battery depth of discharge. Keep in mind that driving habits also affect range.

What kind of batteries does the truck use?

The beauty of my truck is that it uses standard golf-cart batteries. I saw no need to use more expensive lithium-ion or other advanced battery technologies that require a costly charger and protection electronics for each battery. Lead-acid batteries are the most affordable option for do-it-yourself conversions. The technology has been well-refined over many decades and offers great service at a relatively low cost.

How many batteries does the truck have?

I decided that the 16, 6 V batteries, wired in series, would meet my particular driving needs, meaning I would have more than adequate range and speed (60 mph maximum, with no need to travel the freeways).

Can you make an EV go farther than 35 miles and faster than 60 mph?

Absolutely! Speed is related to total battery voltage while distance is related to total battery capacity in amp-hours. In addition, both speed and distance are affected by the total vehicle weight, including batteries. While a full-size pickup truck has a lot of space for batteries, it is also fairly heavy. On the other end, a tiny sports car like a Mazda Miata or MG Midget may be very light but doesn't have much battery space. These cars often have to use lower-capacity, 12 V deep-cycle batteries to get enough voltage for highway speeds, which limits their range. The best-performing vehicle will be something in the middle—a smallish car or pickup truck that is lightweight but still has a good deal of room for batteries.

Who can successfully convert an internal combustion engine vehicle to electricity?

Anyone with basic mechanical and electrical skills can do it. You don't have to be an engineer. All the conversion components are available off the shelf, and there is plenty of help available—not only from many component suppliers, but also from people who have converted their vehicles and are happy to share their experiences. That's why I created www.evhelp.com.

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Pump Up the POWER

GETTING MORE FROM YOUR GRID-TIED PV SYSTEM

by Jeremy Taylor

With grid-tied PV systems becoming more and more popular, it is important for RE professionals and system owners alike to have realistic expectations of their systems' performance. Solar-electric power production can be affected by several factors. In this article, we discuss many of those factors and offer helpful tips for maximizing system performance.

Courtesy iStockphoto/Olaf Loose

PV modules installed in rows and tilted up require careful placement to avoid one row shading the next.

Smart Siting

One of the most important considerations is locating the PV array to maximize solar exposure. Industry experts recommend siting your array in an unobstructed solar window from 9 a.m. to 3 p.m. You can use a solar site analysis tool (Solar Pathfinder, Solmetric Suneye, or Acme Solar Site Evaluation Tool) or a trusty compass and a sun-path chart for your latitude, to determine true south and the solar window at your site.

Shading. Many people—installers and homeowners alike—fail to consider the impact of even negligible shade caused by overhangs, second stories, trees, exhaust vents, and chimneys. Each PV module consists of dozens of cells that, when even partially shaded, will result in decreased performance, which is like throwing KWH and money down the drain. Lower performance means more electricity purchased from the utility, and less financial return on your solar investment. For those systems that qualify for performance-based incentives, even more revenue is lost with poor performance.

Most PV modules today incorporate bypass diodes that can route power around a shaded portion of the module, thus minimizing power losses from localized shading. Because of the resistance caused by an inactive portion of a series circuit, the impact of shading across a series of cells can be severe. Shading is the number-one system performance problem and should be avoided.

Arrays installed in rows and tilted up from the roof plane require special attention to avoid one row shading the next.


Courtesy Jeremy Taylor

Overhangs, second stories, trees, vents, chimneys, etc. can affect the output of a PV system. Some potential shadings are hard to detect in advance without careful siting efforts.

Calculating the distance needed between the rows can be complex, but at least for flat roofs, there is a simple design rule—the space between a row of modules should be at least three times the height of the row in front of it. For example, if a south-facing array is mounted on a flat roof and stands 2 feet tall, each row would start 6 feet behind the row in front of it. This will provide a clear solar window from at least 9 a.m to 3 p.m., even as far north as 45 degrees latitude. In the southern half of the U.S., closer spacing may be possible, but minimum spacing should not be less than two times the height of the adjacent row. Those are minimums—wider spacing may be used to squeeze out a bit more energy production in the early morning and late afternoon.

Another method is to set up a first row, and then move behind it at roof level with a Solar Pathfinder until the no-shade spot is reached—that is where the next row would begin.

In snowy regions, drifts or accumulated snow can further complicate row spacing and array placement. Be sure to provide ample clearance under and around the array to help keep it clear.

Proper Array Orientation & Tilt. An array's orientation and tilt can make a difference in an array's energy production. For best year-round performance in most locations, fixed arrays should be oriented to *true* south—as opposed to magnetic south—which means taking into consideration the site's magnetic declination.

Array tilt also plays an important role in energy production. For optimal production, arrays generally should be tilted at an angle equal to your latitude. However, most PV arrays are mounted parallel to the roof plane, and have the same tilt as the roof, which is typically pitched at an angle less than the latitude. An array mounted parallel to the roof surface at a tilt less than latitude will produce more energy in summer, when some utilities have higher per-KWH rates.

If your site does not allow for true south orientation or tilt equal to latitude, you can simply factor the production losses into your system design and compensate by using a slightly larger array. See the table for design factors that can be used for less than optimal orientations and tilts. To determine the KWH impact of various tilts and other factors for any PV system at any site, use the National Renewable Energy Laboratory's PVWatts online calculator (see Access).

Energy *Can* Grow on Trees

When it comes to shade, trees pose one of the greatest problems. Removing the culprit obstructing the solar window is the obvious and often hasty solution. But before you reach for the chain saw, consider how the offending object affects the solar window over the full year—rather than one moment, day, or season. Chopping down a tree on the west side of your house that shades your PV array on summer afternoons might mean increased power production during that season, but it also might mean that the loss of shade for your house results in having to run the air conditioner more often.

Components

PV Performance Parameters. PV module power ratings (nameplate ratings) are determined at "standard test conditions" (STC)—1,000 watts per square meter of solar irradiance at a PV cell temperature of 25°C (77°F). A system's

PV Array Output Multipliers for Various Orientations & Tilt Angles

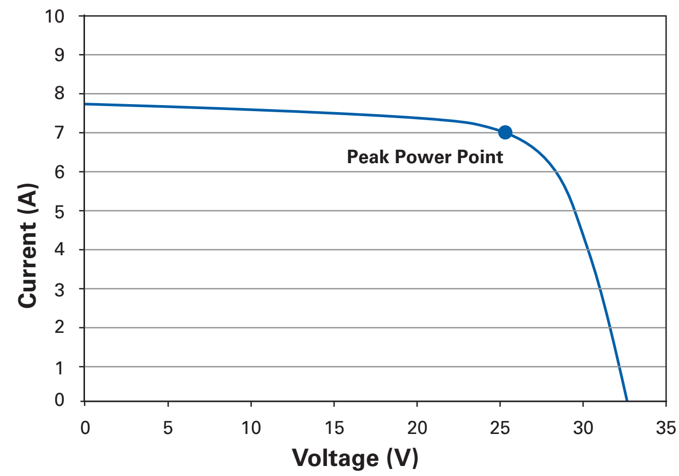
	Array Tilt (From Horizontal)					
Array Orientation	**Hori-zontal**	**15°**	**30°**	**45°**	**60°**	**Vert-ical**
Florida						
South	0.93	0.99	1.00	0.96	0.86	0.57
Southeast or southwest	0.93	0.96	0.96	0.90	0.82	0.57
East or west	0.93	0.91	0.85	0.77	0.68	0.49
California						
South	0.89	0.97	1.00	0.97	0.89	0.58
Southeast or southwest	0.89	0.95	0.96	0.93	0.85	0.60
East or west	0.89	0.88	0.84	0.78	0.70	0.52
Arizona						
South	0.89	0.97	1.00	0.97	0.89	0.60
Southeast or southwest	0.89	0.94	0.95	0.90	0.83	0.59
East or west	0.89	0.87	0.82	0.75	0.66	0.48
New York						
South	0.87	0.96	1.00	0.98	0.92	0.66
Southeast or southwest	0.87	0.93	0.94	0.91	0.85	0.62
East or west	0.87	0.85	0.81	0.74	0.67	0.49

Source: NABCEP/Clean Power Estimator. Multipliers are averages for several locations in each state.

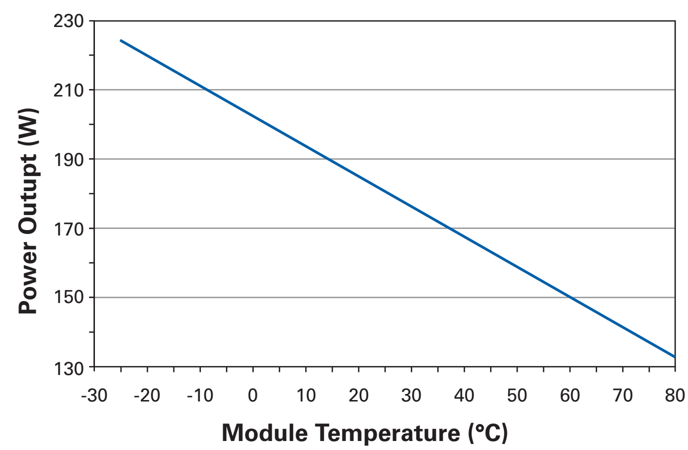
Courtesy Shawn Schreiner (2)

Every new PV module has a label listing its critical specifications.

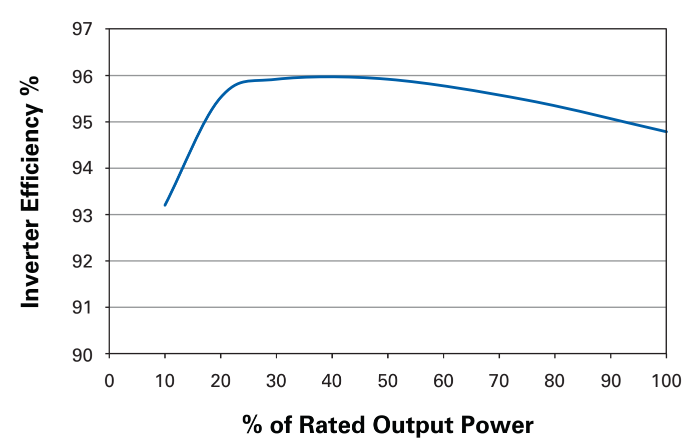
ES-180 STC Current vs. Voltage



ES-180 Power vs. Module Temp.



Example Inverter Efficiency vs. Output Power



size is nominally stated by multiplying the STC rating by the number of modules—but you shouldn't count on this being an accurate reflection of the system's actual output.

STC testing is performed in a laboratory setting where modules are flashed with a light source and power output is measured. This measurement doesn't account for temperature or wind variations, which can drastically affect performance. Like any material exposed to sunlight, PV modules heat up as they absorb solar infrared radiation, becoming less efficient at converting light to electrical energy. For cell temperature to be 77°F, the same as STC, the ambient air temperature has to be much lower (about 23°F to 32°F)—unusually low temperatures in most circumstances.

Another standard, PTC (PVUSA test conditions) was developed to better simulate real-world installations. PTC is conducted at the same irradiance, but at a somewhat more realistic ambient temperature of 68°F (with cell temperature about 113°F), and at a wind speed of 1 meter per second (2.24 mph). Because temperature-related power loss averages -$^{1}/_{2}$% per °C rise for crystalline PV modules, their PTC ratings typically range from 85% to 90% of the STC rating.

The underlying lesson is to provide for sufficient airflow around mounted PV modules to minimize production losses due to heat. In general, allow a 3- to 5-inch unrestricted air gap between the roof and flat-mounted modules. Modules tilted up from the roof plane fare even better—but to some, tilting can be aesthetically undesirable.

Warranted PV Minimum Power Ratings. To most accurately project long-term performance, also consider the module manufacturer's warranted minimum power rating. After modules are placed into service, their power output will decrease over time. Besides initial photon degradation due to the physical process that generally occurs within the first few hours of a PV module's operation, the long-term effects of weather and photon degradation influence module performance over its lifetime. One report estimates that initial degradation will be 0% to 3.9% of a crystalline PV module's performance, while continuous degradation can reduce performance from 0.1% to 1.0% per annum (see Access). Reported degradation values will vary.

Most modules are warranted for minimum peak power output within two different time frames—90% of minimum peak power for 10 years, and 80% for 20 to 25 years. While you can't do much to prevent module degradation, you can select wisely. Before you buy, compare the rated power tolerance for various modules. Most modules have a tolerance of ±5% (or better) of STC-rated power. For example, if a 100 W module has a specified power tolerance of ±5%, then the minimum peak power value for this module will be 95 W, and the module warranty will be based on this value rather than the STC rated power of 100 W. The tighter the tolerance, the more you can be assured that you're getting the wattage that you paid for.

Lastly, because module degradation can result in lower voltage output, be careful when matching a PV array to a particular inverter's input voltage range. Say a grid-tied inverter input window will accept eight to twelve modules in series. After many years in the field, the voltage of the PV array could degrade to the point that on a hot, sunny day, eight modules in series no longer stay within the inverter's input voltage window. To avoid this problem, aim for the higher end of an inverter's input voltage window when you're determining the number of modules in series strings.

Courtesy www.directpower.com

The modules in this array are about six inches off the roof, allowing adequate ventilation to keep them as cool as possible.

Calculating Array Output

A system's power output can be calculated fairly accurately given the array size (rating at STC), module temperature, solar irradiance, inverter efficiency estimation, and a basic system derate value. For this example, assume the system has been installed within the past year and that there is no shading on the modules.

Array size = 4 KW (STC)

Irradiance at array tilt & orientation = 80% of full sun (800 W/m^2)

Module temperature efficiency = 84% (-0.5% per degree over 25°C—57°C assumed for this example)

Inverter "CEC weighted" efficiency = 94%

System losses derate value = 85%

Estimated array output = 4,000 W x 0.80 x 0.84 x 0.94 x 0.85 = 2,148 W

This figure can then be compared with system metering or output measurements to make sure the system is operating as expected.

Module Mismatch. Manufacturing tolerances mean that modules of the same make and model will have slightly different current-voltage characteristics resulting in a decreased efficiency when the modules are connected together—you can figure in a loss of up to 2% because of mismatch. "Module mismatch," as discussed here, is *not* referring to modules of differing make or models being wired together. This is a separate issue—and if mixing modules is done incorrectly it can result in much more significant power loss. If modules are wired in series, then all within the series string should be of the same model and with the same tilt and orientation.

Inverter Inefficiencies. The next consideration in the system loss lineup is inverters, which convert the PV array's DC into AC for household use. Unlike modules, inverters should be installed out of direct sun. Too much heat is a deadly enemy of all electronics, and inverters are no exception. Installing in a high temperature environment can cause a unit to operate less efficiently and may lead to premature component failure. Even inverters that have weather protection and are rated to be installed outdoors must be kept shaded, even if it means installing an awning over them. Likewise, be sure that inverters installed in closets or small rooms have sufficient air circulation to help remove heat buildup.

Most modern inverters are rated at efficiencies of 90% or greater, but actual operating efficiency can vary. One factor that can affect power production is an inverter's maximum power point tracking (MPPT) performance. PV module voltages fluctuate as light and temperature conditions change, and the inverter must be able to work efficiently within a range of voltages. If an inverter's effective MPPT voltage range is too narrow, then production can drop accordingly.

Always consider the efficiency of inverters before buying. A 1% improvement in efficiency can mean thousands of KWH gained over the lifetime of your system, and more money in your pocket. Each inverter lists maximum efficiency in its specifications, but a more realistic value is the "weighted efficiency"—a useful comparison tool for designers and consumers. A weighted efficiency is estimated by assigning a percentage of time the inverter resides in a particular range of operation to approximate its efficiency over the full day. Because available sunlight and array operating conditions are constantly fluctuating, actual array power will vary throughout the day, so weighted efficiency can be a better predictor of system performance.

Miscellany

Line Losses. The amount of energy lost in conductors and electrical connections is known as line loss. The wasted energy from resistive losses—voltage drop in the electrical circuit—from source to load should be designed to be less than 5%. Since voltage drop is additive for each individual wire run within a circuit, keeping the overall voltage drop from source to load under 5% means voltage drops of the individual wire runs will have to be much lower (2% or less). Maximize performance by evaluating and sizing each wiring run individually. Of particular importance is the output circuit from a grid-tied inverter to the main service panel. This wire run usually needs to have a 1% or lower voltage drop to ensure that the inverter has enough excess voltage to be able to push its energy onto the utility grid and to make sure the voltage from the grid stays within the inverter's AC operating window. Using higher voltages and larger conductors means less resistance losses. Additionally, reliable, low-resistance connections between conductors and equipment will help minimize losses.

Soiling. Dirt, dust, bird excrement, and snow can filter out some sunlight from the PV cells. According to the National Renewable Energy Laboratory, modules in areas that experience high levels of particulate pollution and infrequent rain can experience soiling losses of up to 25%, especially on flat-mounted arrays. Isolated soiling that remains for an extended time can cause "hot spots" that prematurely degrade or damage PV cells. It's nothing a squeegee, some water, and a little elbow grease can't conquer—keep your modules clean. In many areas, a periodic rainfall can do the job. But if it's been a long time since the last rain and you notice a fine layer of dirt or dust building up, you will boost your system's energy production with a little cleaning.

Mixed Orientations

Modules from different manufacturers often have very different operating characteristics and dissimilar modules should not be used in the same series string. Likewise, mixed orientations of the same module will have dissimilar operating characteristics. But what if a site's circumstance requires two different orientations? If half of an array faces east and the other half west, isolate the modules from each plane into separate series strings. Then use multiple inverters or an inverter that can track multiple maximum power points (MPPTs), like Magnetek's Aurora inverter. Some grid-tie inverters with only one MPPT may work fine with non-optimal module configurations, but the exact impact is inverter-specific. For example, Fronius says its inverter can handle multiple PV orientations with a loss of 1% or less. But SMA America recommends keeping modules in the same plane for their inverters—no variations, period. So if working with mixed module orientations, and a single MPPT inverter is desired, make sure the inverter you are considering will handle the orientations you want.

Performance Check

System owners should periodically inspect their PV system and check performance to make sure all is functioning correctly. Physically inspect for broken modules and potential shading issues (for example, a growing tree). For checking performance, most grid-connected inverters have a meter that displays the amount of power (W) being produced and how much energy (KWH) has been produced that day and over the lifetime of the inverter.

Some systems may incorporate data-monitoring to remotely check the power and energy production. (See *HP121*, "The Whole Picture: Computer-Based Solutions for PV System Monitoring.") Metering is helpful for a quick check on power production—but if it seems that the system is not performing as well as it should, more information will be needed. Irradiance and temperature, which are not typically a function of standard inverter metering, are constantly fluctuating and can significantly affect system performance; they need to be measured for accurate system assessment.

Other system losses (such as line loss, module mismatch, inverter efficiency, etc.) can also be estimated. PV professionals have basic tools to get a fairly accurate assessment of system performance, such as a hand-held solar irradiance meter and


Courtesy Jeremy Taylor

Keeping modules clean can remarkably increase the output of your system. If you live in a particularly dusty location, you may need to clean your modules monthly.

Microclimates, Peak Power & You

Adjustments to the design of a PV system will need to be made according to the site's microclimate and other local circumstances. For instance, in Colorado, where afternoon clouds are frequent, a more southeasterly array orientation may be favorable, so that the array can receive more direct sunlight when it is available. Similarly, in coastal Central and Northern California, where mornings are often foggy, a more westerly orientation can be beneficial.

Also consider your utility rate structure. Some utilities offer "time of use" (TOU) metering programs—charging more per KWH during peak consumption times, generally mid-afternoon. In states like California, where the grid experiences huge summertime afternoon air-conditioning loads, these rate structures are helpful in keeping grid usage within bounds. TOU programs penalize peak users and reward peak producers in an effort to meet afternoon loads without having to build more generation capacity. That's good news for PV system owners who can get greater net billing KWH credit by making sure their systems perform optimally during those peak times. To capitalize on peak selling rates, systems should be oriented and tilted toward the sun during those hours. And by reducing energy consumption during peak rate times, you can further increase your financial benefit from TOU rates.

an infrared temperature reader. With irradiance and module temperature known, installers can calculate how much power the system should be producing (see Calculating Array Output sidebar) and compare that value to the inverter's meter or a reading on a clamp-on multimeter on the output circuit. If the two values vary significantly, there may be a problem to troubleshoot—perhaps a faulty module, a blown fuse, or poor inverter MPPT performance.

With the significant cost of PV systems and the need to maximize output for production-based incentives, wringing as many KWH as possible out of your system makes economic and environmental sense. Paying attention to installation details and monitoring a system's output over its lifetime will give you the most value from your investment.

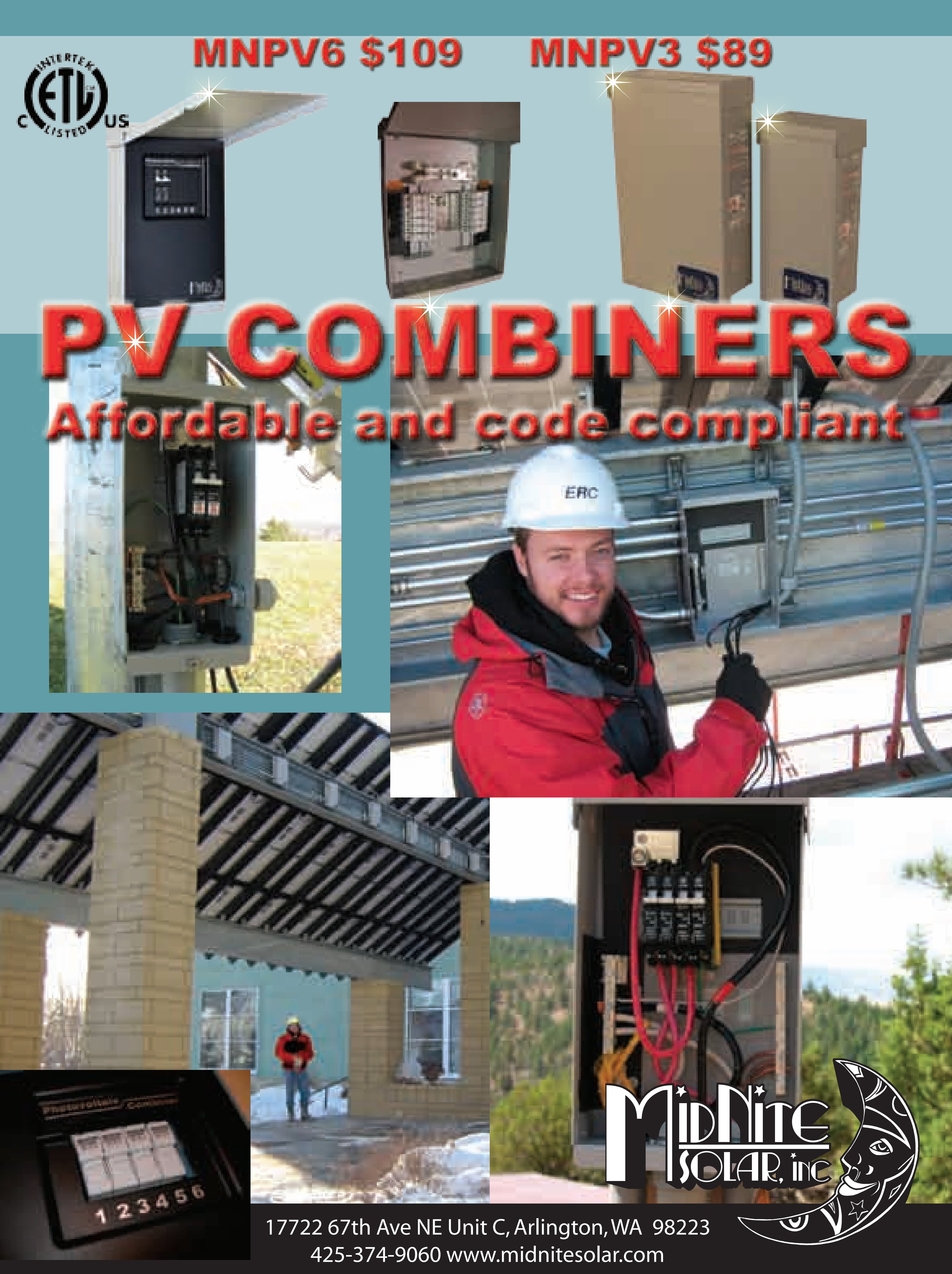
Access

Jeremy Taylor (sun1ness@yahoo.com) is a NABCEP-certified industry veteran, residing in southern California. He began his solar career in 2002, learning from the roof down from PV projects on-grid and off, ranging from 5 W to 1 MW. His focus is primarily on system design and performance monitoring.

PVWatts • http://rredc.nrel.gov/solar/codes_algs/PVWATTS/

Go Solar California • www.gosolarcalifornia.org • List of inverters & their weighted efficiencies

Dunlop, Ewan D. "Lifetime Performance of Crystalline Silicon PV Modules." Proceedings of 3rd World Conference on Photovoltaic Energy Conversion, Volume 3, May 12–16, 2003: 2,927–2,930.


MNPV6 $109
MNPV3 $89
Intertek ETL C US Listed
PV COMBINERS
Affordable and code compliant
ERC
Photovoltaic Combiner
1 2 3 4 5 6
MidNite Solar, inc
17722 67th Ave NE Unit C, Arlington, WA 98223
425-374-9060 www.midnitesolar.com

Choosing the Best Batteries

2009 Battery Specifications Guide

Whether you need batteries to store energy for your off-grid home, or you want backup power to keep the lights on when the grid goes down, understanding the different battery specifications will help you select the ideal batteries for your application.

by Christopher LaForge

To choose the right battery, you first need to know what you are trying to accomplish. What system type are you working with—off-grid or grid-tied? Where will the battery bank be located? How much maintenance are you prepared to do? And how often (or not) do you want to replace your batteries? The answers to these questions will dictate which batteries make the most sense for your renewable energy system.

Budget also plays a big role in which batteries you choose. Buying batteries is a long-term investment, and skimping on these important components can cripple a system. Getting it right the first time will pay off in performance and longevity. However, simply buying the most expensive battery does not ensure you are meeting the needs of your renewable energy system. For your system to operate and perform well, it is crucial to understand the various battery specifications and how they relate to RE system design.

Batteries used in an RE system can be broken down into two basic categories: heavy duty/commercial and industrial. A common heavy duty/commercial-type battery bank may be comprised of several 6 V, 390 AH (L-16 type) batteries. An industrial battery pack will usually be large 2 V cells (with thicker lead plates) pre-wired to 12, 24, or 48 V and encased in a large metal housing. You will pay more for the industrial battery bank than you will for the equivalent battery pack made of heavy duty/commercial batteries, but you gain longer battery life and a better warranty.

If you are working with an installing dealer, they often have preferences about which batteries they will use. For example, some installers will only work with L-16 type batteries because they are the largest that they can readily move by themselves—each L-16 battery weighs around 120 pounds, whereas industrial batteries can weigh thousands of pounds, making them difficult to maneuver without disassembly. If you have no experience with batteries, shorter-lived, less-expensive batteries may be a better choice to get you up to speed with battery operation. But some installers will still lean toward the expensive industrial battery packs because they want to minimize battery replacement. This can be especially beneficial in an off-grid setting where just getting to the site may be difficult—much less moving the old batteries out, getting the new ones in, and having to haul the old ones away for recycling. However, industrial batteries are only a wise investment if you are confident in your ability to maintain the battery bank.

Using This Guide

This guide lists specifications for different lead-acid batteries, the most common chemistry used in RE systems. Exotic technologies such as lithium ion, liquid pocket plate nickel cadmium, nickel iron, and nickel metal hydride batteries are not included here because they are either unavailable or too costly for consideration. Get familiar with battery terms and definitions; they'll give you an understanding of each spec's relevance to designing an optimal battery system.

Choosing Your Batteries

As with any RE system investment, your best bet will be to identify your true needs and design a system around them. Grid-tied battery backup systems generally use low-capacity banks made up of sealed, non-industrial batteries that will meet your needs for running critical loads like refrigeration and lighting during power outages. They are generally designed to stay at float most of the time with only occasional cycling, and are often made with calcium alloyed with the lead which helps lower battery self-discharge losses.

Courtesy www.discover-energy.com

Most battery manufacturers have a full line of products in different amp-hour capacities and voltages.

A classic Trojan L-16H flooded lead-acid battery—420 AH at 6 V.

To properly size a backup battery bank, compute your critical load profile to determine daily watt-hour consumption during power outages. That number can often be your guide for the correct battery size. Most grid outages are less than one day, and a battery bank sized to be discharged to 50% of capacity by the critical load profile will meet most needs nicely.

If you're off grid and rely on your batteries to meet all your electrical loads, buy a long-lived battery and be prepared to maintain it well. These systems—which cycle the batteries daily—use batteries with a lead-antimony alloy, which performs better under conditions of regular cycling.

Typically, off-grid battery banks are sized by considering the required "autonomy"—the number of days that the battery will provide for the loads before reaching 50% depth of discharge (DOD). Off-grid systems usually size a bank to provide two to four days of autonomy. For example, if your load profile requires 5,000 WH per day, you'll want a battery that stores 10,000 WH to achieve one day of autonomy. Four days of autonomy would require a 40,000 WH battery capacity.

Off-grid system designer opinions on maximum DOD vary widely. Some prefer to keep the depth no greater than 20%, while others have no fear of going below 50%. The deeper the regular discharge, the fewer cycles a battery will give you before needing replacement. So if you do not mind swapping your battery bank more often, go with a deeper discharge—it will save you money up front. But if swapping batteries into and out of your system is a royal pain, you might prefer maximizing battery life by buying a higher-capacity battery. For the design choice that will save you money in the long run, calculate the savings from buying fewer batteries up front, plus the cost of more frequent battery replacement (higher DOD)—versus more batteries up front, with fewer replacements (lower DOD).

Better Buy...Now

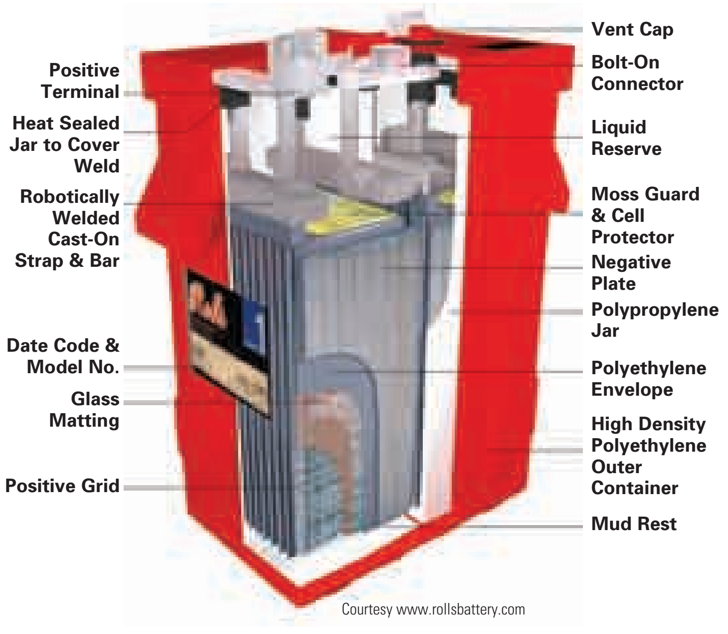
Lead prices are affecting battery costs dramatically and will continue to do so for the immediate future, since batteries represent more than 70% of the lead market. Between 2003 and 2006, lead prices increased by more than 250%, and 2007 saw significant increases as well. Trends indicate that if you need lead-acid batteries, don't put off your purchase—prices may continue rising.

...And Don't Forget

To maximize battery life, batteries need to be properly maintained by:

- Making sure the batteries get completely recharged at least once a week by RE generation and/or supplemented with backup generator or grid charging
- Monitoring the electrolyte and adding distilled water when needed if flooded batteries are used
- Keeping the terminals and interconnections clean by removing built-up corrosion and keeping the battery tops clean and dry
- Equalizing the batteries four to six times a year to remove surface sulfation from the lead plates

Anatomy of an FLA Battery



Specs Definitions

Manufacturer. Battery manufacturers build batteries for many different applications. Historically, RE systems used batteries originally designed for other applications, such as powering electric golf carts. Today, many battery manufacturers list which of their batteries are appropriate for RE systems. All battery manufacturer Web sites listed in this guide, with the exception of FullRiver Battery, list batteries specifically for use in RE systems.

Model name. These letters and numbers are used by the battery manufacturer to "name" a group of batteries that have similar characteristics, and distinguish them from the company's other battery lines. It is important to not use batteries with differing model numbers within the same battery bank, as mixing different battery types can create an imbalance within the pack which leads to poor system performance and may cause premature battery bank failure.

Battery type. *Flooded lead-acid (FLA)* batteries are the most common type used in RE systems, particularly off grid. They are the least expensive per capacity and, if well maintained, can have a relatively long life span. However, they require the most maintenance. Distilled water needs to be added to the cells on a regular basis, depending upon how often and how deeply the bank is cycled, and upon battery charging regimens.

Valve-regulated lead-acid batteries (VLRA, a.k.a. sealed batteries). Two general types of VRLA batteries are available for RE systems—absorbed glass mat and gel cells. **Absorbed glass mat (AGM)** lead-acid batteries are similar in chemistry to FLA cells. In their construction, glass mats, placed between the lead plates (anodes and cathodes), allow the electrolyte to be suspended close to the plates' active material. These sealed batteries offer the advantage of not needing to be watered and greatly reduced gassing during charge cycles. This type of construction—adding glass mats, sealing the cells, and constructing the plates to operate with less electrolyte—increases cost while potentially shortening life span.

Gel cells use a "gel"-type electrolyte—with a silica additive that causes the liquid to stiffen. Gel-cell batteries are also sealed, which means no water to add—less maintenance and less gassing. However, because lost electrolyte cannot be replaced, they also have a shorter life. They are typically more expensive than FLA or AGM batteries.

Courtesy www.usbattery.com

Golf cart batteries are inexpensive but shorter-lived than industrial batteries. They can be good "starter" batteries for people new to battery use and maintenance.

Courtesy www.rollsbattery.com

Some large, industrial batteries, like this Surrette model, come in single 2 V cells.

Because AGMs can't be watered, they have to be charged more lightly to avoid using up the finite amount of electrolyte they contain. Gel cells also aren't watered but need to be charged even more lightly to avoid drying out the cell, which will kill it.

So why would you ever choose shorter-lived, more expensive batteries like AGM or gel cells? The reasons vary, but often portability, poor battery area ventilation, and maintenance are factors. AGM and gel cell batteries have no liquid electrolyte to spill, so they can be a good choice for mobile systems. And because they hardly gas, they can work well in places where adequate ventilation for FLA batteries isn't possible. Because they are freeze-resistant, they may be a good choice in applications where extreme cold is a factor.

AGM batteries are often the best choice for grid-tied applications with battery backup, since they are designed for float or standby applications. Because low-capacity battery banks are typical in backup applications, both decreased

Battery Recycling & Replacement

You've taken care of your batteries throughout their life, and the care shouldn't stop there. Once batteries reach the end of their useful life, recycling your old batteries is as important as replacing them.

The depleted batteries from my customers go back to the U.S.-based factory they came from for recycling at a facility that is regulated by the U.S. Environmental Protection Agency. Although this costs more than the distributor shipping them off to a recycling plant in China or Africa, it also means that the batteries' plastic cases, electrolyte, and lead are all recycled under strict environmental regulations, and the job is done here—where we are making the pollution in the first place.

Batteries sold by reputable dealers are recycled by them at no cost to the customer. Most often, when replacing batteries, you can send back the old cells once the new cells are delivered. If you are working with only a few cells, you can typically return them to the distributor for recycling when you pick up your new battery. Most distributors require the return of the old battery to avoid a "core charge" being added to the purchase of the new battery.

Specs for Flooded Batteries for Home RE Systems

Manufacturer	Model	Nom. Volts	AH Capacity (20 Hr. Rate)	Bulk Charge Set Point (V/Cell)	Float Charge Set Point (V/Cell)	Equalize Charge Set Point (V/Cell)	Length x Width x Height (In.)	Wt. (Lbs.)	War-ranty (Yrs.)	Cycles @ 20% DOD	Cycles @ 50% DOD
Deka/MK www.eastpenn-deka.com	8L16	6	370	2.40–2.45	2.30–2.35	2.50–2.55	11.75 x 7 x 17.3	113	2	1,100	800
	EPGC15G	6	215	2.40–2.45	2.30–2.35	2.50–2.55	10.25 x 7.13 x 10.63	63	2	1,100	800
Exide Battery www.exide.com	OPzS Solar Cell	2	145–3,765*	2.45	2.35	2.45	4.13–8.46 x 8.19–22.83 x 15.94–32.09	14–217	1	3,500	1,500
	OPzS Solar Block	12	68–178*	2.45	2.35	2.45	10.80–15.07 x 8.19 x 15.16	35–64	1	3,500	1,500
Hawker www.hawkerpowersource.com	6-85-13	12	632	2.45	2.25	2.55	31 x 6 x 24	510	10	6,000	4,000
	6-85-17	12	845	2.45	2.25	2.55	38.25 x 7 x 24	666	10	6,000	4,000
	6-85-19	12	950	2.45	2.25	2.55	38.25 x 7.7 x 24	740	10	6,000	4,000
	6-85-21	12	1,055	2.45	2.25	2.55	38.25 x 8.5 x 24	816	10	6,000	4,000
	6-85-23	12	1,160	2.45	2.25	2.55	38.25 x 9.2 x 24	890	10	6,000	4,000
	6-85-25	12	1,270	2.45	2.25	2.55	38.25 x 10 x 24	966	10	6,000	4,000
	6-85-27	12	1,375	2.45	2.25	2.55	38.25 x 10.7 x 24	1,045	10	6,000	4,000
	6-85-29	12	1,482	2.45	2.25	2.55	38.25 x 11.5 x 24	1,116	10	6,000	4,000
	6-85-31	12	1,585	2.45	2.25	2.55	38.25 x 12.2 x 24	1,195	10	6,000	4,000
	6-85-33	12	1,690	2.45	2.25	2.55	38.25 x 13 x 24	1,272	10	6,000	4,000
GB HUP www.enersysmp.com	SO-6-85-17/12	12	845	2.40–2.46	2.25	2.50–2.70	40 x 7.75 x 25	742	10	4,000	2,730
	SO-6-85-21/12	12	1,055	2.40–2.46	2.25	2.50–2.70	40 x 8.75 x 25	880	10	4,000	2,730
	SO-6-85-27/12	12	1,375	2.40–2.46	2.25	2.50–2.70	40 x 11.25 x 25	1,102	10	4,000	2,730
	SO-6-85-33/12	12	1,690	2.40–2.46	2.25	2.50–2.70	40 x 13.5 x 25	1,336	10	4,000	2,730
	SO-6-85-17/24	24	845	2.40–2.46	2.25	2.50–2.70	40 x 15.5 x 25	1,484	10	4,000	2,730
	SO-6-85-21/24	24	1,055	2.40–2.46	2.25	2.50–2.70	40 x 17.5 x 25	1,760	10	4,000	2,730
	SO-6-85-27/24	24	1,375	2.40–2.46	2.25	2.50–2.70	40 x 22.5 x 25	2,204	10	4,000	2,730
	SO-6-85-33/24	24	1,690	2.40–2.46	2.25	2.50–2.70	40 x 27 x 25	2,672	10	4,000	2,730
	SO-6-85-17/48	48	845	2.40–2.46	2.25	2.50–2.70	40 x 31 x 25	2,968	10	4,000	2,730
	SO-6-85-21/48	48	1,055	2.40–2.46	2.25	2.50–2.70	40 x 35 x 25	3,520	10	4,000	2,730
	SO-6-85-27/48	48	1,375	2.40–2.46	2.25	2.50–2.70	40 x 45 x 25	4,408	10	4,000	2,730
	SO-6-85-33/48	48	1,690	2.40–2.46	2.25	2.50–2.70	40 x 54 x 25	5,344	10	4,000	2,730
Power Battery www.powerbattery.com	120HPF-25	2	2,160	2.40–2.50	2.20–2.23	2.55–2.65	9.8 x 6.56 x 30.5	217	10	4,000	2,900
	120HPF-33	2	2,880	2.40–2.50	2.20–2.23	2.55–2.65	12.8 x 6.56 x 30.5	324	10	4,000	2,900
	6-120HPF-15	12	1,053*	2.40–2.50	2.20–2.23	2.55–2.65	17.8 x 13 x 30.5	780	10	4,000	2,900
	SG-L16H	6	395	2.50	2.26	2.60	12.19 x 7.19 x 16.5	121	1	—	—
Surrette/ Rolls Battery www.surrette.com	2-KS-33PS	2	1,766	2.40–2.49	2.20–2.23	2.50–2.67	15.44 x 8.3125 x 24.8125	208	10	5,000	3,300
	2-YS-31PS	2	2,430	2.40–2.49	2.20–2.23	2.50–2.67	15.5 x 9 x 31.625	285	10	5,000	3,300
	4-CS-17PS	4	546	2.40–2.49	2.20–2.23	2.50–2.67	14.375 x 8.25 x 18.25	128	10	5,000	3,300
	4-KS-21PS	4	1,104	2.40–2.49	2.20–2.23	2.50–2.67	15.75 x 9.375 x 24.75	267	10	5,000	3,300
	4-KS-25PS	4	1,350	2.40–2.49	2.20–2.23	2.50–2.67	15.75 x 10.625 x 24.75	315	10	5,000	3,300
	6-CS-17PS	6	546	2.40–2.49	2.20–2.23	2.50–2.67	22 x 8.25 x 18.25	221	10	5,000	3,300
	6-CS-21PS	6	683	2.40–2.49	2.20–2.23	2.50–2.67	22 x 9.75 x 18.25	271	10	5,000	3,300
	6-CS-25PS	6	820	2.40–2.49	2.20–2.23	2.50–2.67	22 x 11.25 x 18.25	318	10	5,000	3,300
	S-460	6	350	2.40–2.49	2.20–2.23	2.50–2.67	12.25 x 7.125 x 16.75	117	7	2,000	1,200
	S-530	6	400	2.40–2.49	2.20–2.23	2.50–2.67	12.25 x 7.125 x 16.75	127	7	2,000	1,200
	8-CS-17PS	8	546	2.40–2.49	2.20–2.23	2.50–2.67	28.25 x 8.25 x 18.25	294	10	5,000	3,300
	8-CS-25PS	8	820	2.40–2.49	2.20–2.23	2.50–2.67	28.25 x 11.25 x 18.25	424	10	5,000	3,300
	12-CS-11PS	12	357	2.40–2.49	2.20–2.23	2.50–2.67	22 x 11.25 x 18.25	272	10	5,000	3,300
Trojan Battery www.trojan-battery.com	J305H	6	335	2.40–2.45	2.00–2.25	2.58	11.63 x 7 x 14.38	97	1	2,800	1,300
	J305P	6	315	2.40–2.45	2.00–2.25	2.58	11.63 x 7 x 14.38	95	1	2,800	1,300
	L16H	6	420	2.40–2.45	2.00–2.25	2.58	11.63 x 7 x 16.75	124	7	2,800	1,300
	L16P	6	390	2.40–2.45	2.00–2.25	2.58	11.63 x 7 x 16.75	113	7	2,800	1,300
	T105	6	225	2.40–2.45	2.00–2.25	2.58	10.38 x 7.13 x 10.88	62	1.5	2,800	1,300
	24TMX	12	85	2.40–2.45	2.00–2.25	2.58	11.25 x 6.75 x 9.75	47	1	2,800	1,300
	27TMX	12	105	2.40–2.45	2.00–2.25	2.58	12.75 x 6.75 x 9.75	55	1	2,800	1,300

*24 hr. rate

Specs for Flooded Batteries for Home RE Systems, cont.

Manufacturer	Model	Nom. Volts	AH Capacity (20 Hr. Rate)	Bulk Charge Set Point (V/Cell)	Float Charge Set Point (V/Cell)	Equalize Charge Set Point (V/Cell)	Length x Width x Height (In.)	Wt. (Lbs.)	War-ranty (Yrs.)	Cycles @ 20% DOD	Cycles @ 50% DOD
US Battery www.usbattery.com	L16	6	380	2.58	2.20	2.67	11.875 x 7.125 x 16.75	111	1	3,300	1,150
	L16HC	6	420	2.58	2.20	2.67	11.875 x 7.125 x 16.75	117	1	3,300	1,150
	US125	6	242	2.58	2.20	2.67	10.25 x 7.125 x 11.25	65	1	3,300	1,150
	US145	6	251	2.58	2.20	2.67	10.25 x 7.125 x 11.875	69	1	3,300	1,150
	US2200	6	232	2.58	2.20	2.67	10.25 x 7.125 x 11.25	62	1	3,300	1,150
	US250	6	258	2.58	2.20	2.67	11.875 x 7.125 x 11.625	72	1	3,300	1,150
	US250HC	6	283	2.58	2.20	2.67	11.875 x 7.125 x 11.625	78	1	3,300	1,150
	US305	6	310	2.58	2.20	2.67	11.875 x 7.125 x 14.625	87	1	3,300	1,150
	US305HC	6	340	2.58	2.20	2.67	11.875 x 7.125 x 14.625	96	1	3,300	1,150
	US8VGC-HC	8	183	2.58	2.20	2.67	10.25 x 7.125 x 11.25	69	1	3,300	1,150
	8D-HC	12	240	2.58	2.20	2.67	20.75 x 11.25 x 9.875	124	1	3,300	1,150
	US185	12	200	2.58	2.20	2.67	15.625 x 7.0625 x 14.875	109	1	3,300	1,150
	US185HC	12	220	2.58	2.20	2.67	15.625 x 7.0625 x 14.875	120	1	3,300	1,150

cycle life and increased cost can be offset by the fact that these batteries are rarely cycled. Plus, users with grid-tied systems are usually less inclined to pay attention to the battery maintenance, since they are also unaccustomed to "maintaining" their grid power. Finally, VRLA batteries will outlast FLA batteries that are not maintained properly (i.e. not watered regularly). If batteries are to be deeply cycled (50% to 80% DOD), gel-cell batteries may offer a longer life (more overall cycles) than AGMs.

Nominal Battery Voltage. Lead-acid batteries are built from individual cells with a "nominal" voltage of 2 V. Battery packs for RE systems are made up of combinations of cells to achieve nominal battery bank voltages of 12, 24, or 48. When designing small systems (loads less than 1,000 WH per day), 12 VDC is often selected as a nominal battery bank voltage if that system is not projected to grow. So a system for a hunting cabin that isn't going to become a vacation home will keep battery costs down by having this low-voltage design.

Courtesy www.solaronebatteries.com

This Hup industrial battery from Northwest Energy Storage demonstrates how single cells are contained in protective steel cases.

For systems with heavier load profiles, larger (and more electrically efficient) battery voltages of 24 and 48 are commonly used. With commercial deep-cycle batteries (like golf cart and L16), the basic unit is often a 6 V battery made up of three, 2 V cells. In the medium-to-large systems, these 6 V units are typically combined in series (four for a 24 V string; eight for a 48 V string). To get greater AH capacity at that voltage, additional strings are then paralleled or higher-capacity batteries are selected.

Amp-Hour Capacity. The sizing of the battery bank depends on the storage capacity required, the maximum discharge rate at any time, the maximum charge rate, and the temperatures at which the batteries will operate.

A battery's storage capacity—the amount of electrical energy it can hold—is typically expressed in ampere-hours (amp-hours, or AH) at a certain discharge rate. One AH represents a flow of electric current of 1 amp for 1 hour. A battery is like a bucket—the larger your "bucket" is, the more AH it can hold. Hence, the larger the AH value of a battery, given a particular discharge rate, the more storage it offers.

Often there's a choice of selecting a battery with either higher voltage and lower AH, or lower voltage and higher AH. How do you know which is most appropriate for your application? In general, limit the number of battery series strings in parallel to three or less (two are better, and one is ideal). This reduces imbalances introduced by having multiple paths for the current to follow and

Specs for Sealed Batteries for Home RE Systems

Manufacturer	Model	Type (AGM or Gel)	Nom. Volts	AH Capacity (20 Hr. Rate)	Bulk Charge Set Point (V/Cell)	Float Charge Set Point (V/Cell)	Equalize Charge Set Point (V/Cell)	Length x Width x Height (In.)	Wt. (Lbs.)	War-ranty (Yrs.)	Cycles @ 20% DOD	Cycles @ 50% DOD
Concorde Battery www.concordebattery.com	PVX-5040T	AGM	2	480	2.36–2.40	2.20–2.22	2.40	10.21 x 6.6 x 8.93	57	1	2,800	1,050
	PVX-5340T	AGM	2	510	2.36–2.40	2.20–2.22	2.40	12.9 x 6.75 x 8.96	62	1	2,800	1,050
	PVX-6240T	AGM	2	600	2.36–2.40	2.20–2.22	2.40	12.01 x 6.6 x 8.93	66	1	2,800	1,050
	PVX-6480T	AGM	2	630	2.36–2.40	2.20–2.22	2.40	12.9 x 6.75 x 8.96	70	1	2,800	1,050
	PVX-6720T	AGM	2	660	2.36–2.40	2.20–2.22	2.40	10.28 x 7.06 x 10	70	1	2,800	1,050
	PVX-9150T	AGM	2	900	2.36–2.40	2.20–2.22	2.40	10.28 x 7.06 x 13.02	94	1	2,800	1,050
	PVX-2240T	AGM	6	220	2.36–2.40	2.20–2.22	2.40	10.28 x 7.06 x 10	67	1	2,800	1,050
	PVX-3050T	AGM	6	300	2.36–2.40	2.20–2.22	2.40	10.28 x 7.06 x 13.02	91	1	2,800	1,050
	PVX-1040T	AGM	12	98	2.36–2.40	2.20–2.22	2.40	12 x 6.6 x 8.93	66	1	2,800	1,050
	PVX-1080T	AGM	12	104	2.36–2.40	2.20–2.22	2.40	12.9 x 6.75 x 8.96	70	1	2,800	1,050
	PVX-2120L	AGM	12	210	2.36–2.40	2.20–2.22	2.40	20.76 x 8.7 x 9.76	138	1	2,800	1,050
	PVX-2580L	AGM	12	255	2.36–2.40	2.20–2.22	2.40	20.76 x 10.89 x 9.77	165	1	2,800	1,050
	PVX-690T	AGM	12	65	2.36–2.40	2.20–2.22	2.40	10.22 x 6.6 x 8.93	51	1	2,800	1,050
	PVX-840T	AGM	12	80	2.36–2.40	2.20–2.22	2.40	10.22 x 6.6 x 8.93	57	1	2,800	1,050
	PVX-890T	AGM	12	85	2.36–2.40	2.20–2.22	2.40	12.9 x 6.75 x 8.96	62	1	2,800	1,050
Deka / MK www.eastpenn-deka.com	8AGC2	AGM	6	187	2.40–2.43	2.25–2.30	—	10.25 x 7.13 x 11	68	1	1,600	500
	8A24	AGM	12	78	2.40–2.43	2.25–2.30	—	10.25 x 6.75 x 9.88	53	1	1,600	500
	8A27	AGM	12	92	2.40–2.43	2.25–2.30	—	12.75 x 6.88 x 9.25	63	1	1,600	500
	8A31DT	AGM	12	104	2.40–2.43	2.25–2.30	—	12.94 x 6.75 x 9.38	69	1	1,600	500
	8A4D LTP	AGM	12	198	2.40–2.43	2.25–2.30	—	20.75 x 8.5 x 11	129	1	1,600	500
	8A8D LTP	AGM	12	244	2.40–2.43	2.25–2.30	—	20.75 x 11 x 11	158	1	1,600	500
	8GGC2	Gel	6	180	2.30–2.35	2.25–2.30	—	10.25 x 7.13 x 10.88	68	2	3,000	1,000
	8G24	Gel	12	74	2.30–2.35	2.25–2.30	—	10.88 x 6.75 x 9.88	53	2	3,000	1,000
	8G27	Gel	12	86	2.30–2.35	2.25–2.30	—	12.75 x 6.75 x 9.88	63	2	3,000	1,000
	8G30H	Gel	12	98	2.30–2.35	2.25–2.30	—	12.94 x 6.75 x 9.75	70	2	3,000	1,000
	8G4D LTP	Gel	12	183	2.30–2.35	2.25–2.30	—	20.75 x 8.5 x 10.63	127	2	3,000	1,000
	8G8D LTP	Gel	12	225	2.30–2.35	2.25–2.30	—	20.75 x 11 x 10.63	157	2	3,000	1,000
Discover Energy www.discover-energy.com	EV216A-A	AGM	2	1,170	2.40–2.45	2.25–2.30	—	11.6 x 7.1 x 16.8	123	2	3,500	1,500
	EV250A-A	AGM	6	260	2.40–2.45	2.25–2.30	—	11.6 x 7.1 x 11.7	79	2	3,500	1,500
	EV305A-A	AGM	6	312	2.40–2.45	2.25–2.30	—	11.6 x 7.1 x 14.5	108	2	3,500	1,500
	EVGC6A-A	AGM	6	213	2.40–2.45	2.25–2.30	—	10.2 x 7.1 x 10.8	66	2	3,500	1,500
	EVGH6A	AGM	6	225	2.40–2.45	2.25–2.30	—	10.2 x 7.1 x 10.8	77	2	3,500	1,500
	EVGT6A	AGM	6	255	2.40–2.45	2.25–2.30	—	10.2 x 7.1 x 11.6	86	2	3,500	1,500
	EVL16A-A	AGM	6	390	2.40–2.45	2.25–2.30	—	11.6 x 7.1 x 16.8	123	2	3,500	1,500
	EV805A	AGM	8	230	2.40–2.45	2.25–2.30	—	10.2 x 7.1 x 14.5	102	2	3,500	1,500
	EV816A	AGM	8	312	2.40–2.45	2.25–2.30	—	11 x 7.12 x 15.7	117	2	3,500	1,500
	EVGC8A-A	AGM	8	170	2.40–2.45	2.25–2.30	—	10.2 x 7.1 x 10.8	64	2	3,500	1,500
	EV12A-A	AGM	12	140	2.40–2.45	2.25–2.30	—	12.9 x 6.93 x 10.8	90	2	3,500	1,500
	EV185A-A	AGM	12	234	2.40–2.45	2.25–2.30	—	15.2 x 7.1 x 14.4	147	2	3,500	1,500
	EV27A-A	AGM	12	92	2.40–2.45	2.25–2.30	—	12.7 x 6.7 x 8.9	61	2	3,500	1,500
	EV4DA-A	AGM	12	245	2.40–2.45	2.25–2.30	—	20.8 x 8.7 x 9.9	141	2	3,500	1,500
	EV8DA-A	AGM	12	290	2.40–2.45	2.25–2.30	—	20.8 x 11.1 x 9.9	181	2	3,500	1,500
Exide www.exide.com	Absolyte 100G	AGM	2	600–4,800	2.35	2.25	2.35	19.93–42.50 x 26.38 x 8.59	55–795	7	5,000	2,250
	Absolyte 50G	AGM	2	106–700	2.35	2.25	2.35	17.19–35.19 x 16.22 x 8.53	26–59	7	5,000	2,250
	Absolyte 90G	AGM	2	260–620	2.35	2.25	2.35	21.69–39.69 x 23.56 x 8.53	53–106	7	5,000	2,250
	Sunlyte	AGM	12	82	2.35	2.25	2.35	12.05 x 6.85 x 8.8	70	5	1,000	600
Exide Sonnenschein www.exide.com	A600	Gel	2	225–3,400	2.45	2.35	2.45	4.13–8.47 x 7.60–22.80 x 15.70–32.10	43–529	1	3,500	1,900
	S12/130A	Gel	12	110	2.45	2.35	2.45	11.26 x 10.59 x 9.06	87	1	2,500	1,000
	S12/230A	Gel	12	200	2.45	2.35	2.45	20.39 x 10.79 x 9.37	148	1	2,500	1,000
	S12/90A	Gel	12	84	2.45	2.35	2.45	12.99 x 6.73 x 9.29	66	1	2,500	1,000
FullRiver www.fullriver.com	DC250-6	AGM	6	250	2.40	2.25	—	10.39 x 7.13 x 10.31	77	5	2,900	1,100
	DC310-6	AGM	6	310	2.40	2.25	—	11.61 x 7 x 14.41	105	5	2,900	1,100
	DC400-6	AGM	6	400	2.40	2.25	—	11.61 x 7 x 16.69	123	5	2,900	1,100
	DC100-12	AGM	12	100	2.40	2.25	—	12.09 x 6.65 x 8.46	68	5	2,900	1,100
	DC110-12	AGM	12	110	2.40	2.25	—	12.91 x 6.77 x 8.43	75	5	2,900	1,100
	DC200-12	AGM	12	200	2.40	2.25	—	20.87 x 8.23 x 8.58	144	5	2,900	1,100
	DC240-12	AGM	12	240	2.40	2.25	—	20.47 x 10.59 x 8.19	172	5	2,900	1,100
	DC85-12	AGM	12	85	2.40	2.25	—	10.24 x 6.69 x 8.46	63	5	2,900	1,100
Hawker www.hawkerpowersource.com	6-75EL-09	Gel	12	369	2.35	2.25	No!	38 x 4 x 23.5	390	5	3,300	N/A
	6-75EL-13	Gel	12	553	2.35	2.25	No!	38 x 5.5 x 23.5	564	5	3,300	N/A
	6-75EL-17	Gel	12	738	2.35	2.25	No!	38.25 x 7 x 23.5	720	5	3,300	N/A
	6-75EL-21	Gel	12	925	2.35	2.25	No!	38.25 x 8.5 x 23.5	900	5	3,300	N/A
	6-75EL-25	Gel	12	1,110	2.35	2.25	No!	38.25 x 10 x 23.5	1,080	5	3,300	N/A

Specs for Sealed Batteries for Home RE Systems, cont.

Manufacturer	Model	Type (AGM or Gel)	Nom. Volts	AH Capacity (20 Hr. Rate)	Bulk Charge Set Point (V/Cell)	Float Charge Set Point (V/Cell)	Equalize Charge Set Point (V/Cell)	Length x Width x Height (In.)	Wt. (Lbs.)	War-ranty (Yrs.)	Cycles @ 20% DOD	Cycles @ 50% DOD
Power Battery www. powerbattery. com	PSG-6255	Gel*	6	220	2.33–2.36	2.25–2.30	2.37	10.7 x 7.38 x 10.9	78	2	1,900	1,000
	PSG-12105	Gel*	12	91	2.33–2.36	2.25–2.30	2.37	12 x 6.57 x 9.31	71	2	1,900	1,000
	PSG-12105F	Gel*	12	91	2.33–2.36	2.25–2.30	2.37	21 x 4.25 x 9.63	77	2	1,900	1,000
	PSG-12120	Gel*	12	110	2.33–2.36	2.25–2.30	2.37	13.5 x 6.76 x 9.13	81	2	1,900	1,000
	PSG-12165	Gel*	12	142	2.33–2.36	2.25–2.30	2.37	13.5 x 6.76 x 10.9	101	2	1,900	1,000
	PSG-12255	Gel*	12	220	2.33–2.36	2.25–2.30	2.37	21 x 8.5 x 10	178	2	1,900	1,000
	EZS-242040	Gel*	24	2,040	2.33–2.36	2.25–2.30	2.37	20.30 x 2 x 23.7 x 53	2,836	2	1,900	1,000
	EZS-481020	Gel*	48	1,020 **	2.33–2.36	2.25–2.30	2.37	20.30 x 2 x 23.7 x 53	2,836	2	1,900	1,000
	EZS-482040	Gel*	48	2,040 **	2.33–2.36	2.25–2.30	2.37	20.30 x 4 x 23.7 x 53	5,672	2	1,900	1,000
	EZS-48510	Gel*	48	510 **	2.33–2.36	2.25–2.30	2.37	20.3 x 23.7 x 45	1,418	2	1,900	1,000
Trojan www. trojan-battery. com	27-AGM	AGM	12	100	2.35–2.45	2.30	—	12 x 6.63 x 9.19	67	1	1,200	500
	31-AGM	AGM	12	110	2.35–2.45	2.30	—	13.06 x 6.88 x 8.69	74	1	1,200	500
	8D-AGM	AGM	12	230	2.35–2.45	2.30	—	20.5 x 10.56 x 8.88	167	1	1,200	500
	6V-Gel	Gel	6	189	2.35–2.40	2.20	—	10.25 x 7.13 x 10.88	68	1	2,800	1,300
	24-Gel	Gel	12	77	2.35–2.40	2.20	—	10.88 x 6.75 x 9.31	52	1	2,800	1,300
	27-Gel	Gel	12	91	2.35–2.40	2.20	—	12.75 x 6.75 x 9.25	63	1	2,800	1,300
	31-Gel	Gel	12	102	2.35–2.40	2.20	—	12.94 x 6.75 x 9.63	69	1	2,800	1,300

*Combined AGM/gel design **100 hr. rate

extra electrical resistance created by paralleled battery cables. In applications where more AH are needed, buy lower-voltage, higher AH batteries so that several low-voltage batteries can be wired in series and the number of paralleled battery strings can be minimized.

The denoted AH capacity of a given battery depends on the rate at which it is being discharged and the amount of time it takes to discharge it. Large industrial batteries, i.e. for forklifts, are often rated at the "6-hour" rate, indicating a high current discharge rate, which brings the battery to its terminal voltage (often at 80% DOD) in 6 hours, about the length of a forklift's working shift. For RE systems, a 20-hour rate is typically used, because that is closely aligned with the more modest discharge rates that bring the battery to a terminal voltage (again, often at 80% DOD) over 20 hours—more closely approximating daily home use before recharging.

For converting 6-hour rates to an RE system's more common 20-hour rate, multiply by 1.24. Using this calculation, a 100 AH, 6-hour rating offers 124 AH at the 20-hour rate.

Bulk Charge Set Point Voltage. When charging batteries, the goal is to put as much current as possible into the battery as efficiently as possible. But charging a battery too quickly can cause heat to build up in the battery, as well as excessive gassing, and can shorten the battery's life. To keep from harming the battery during charging, charge controllers used in RE systems limit the charge rate based on the batteries' voltage. As the cell voltage increases, the charge rate (the number of amps allowed in) is reduced to prevent overcharging.

The initial phase when all available current is allowed into the battery is referred to as the "bulk" charge phase. Once the battery has reached its initial bulk-charge voltage, the charge controller will hold the voltage there for a

Courtesy www.bogartengineering.com

An AH meter like the Bogart Engineering Tri-Metric is an important tool for monitoring battery state-of-charge.

Courtesy www.powerbattery.com

A single 2 V FLA cell, in a protective steel case.

programmed period of time (often 2 hours)—the "absorption" charge phase. This is done to assure full charging throughout the many cells of the battery. Note that the set points listed in this guide are per cell, so you will need to multiply it by the number of series-connected cells to determine the appropriate battery charge set points. For example, if you were to use four batteries (6 V each, wired in series for a 24 V configuration) and the bulk charge set point voltage range is 2.4 to 2.49 V for your battery's cells, the ideal battery bank bulk-charge voltage set point would be between 28.8 and 29.88 V (3 cells per battery x 4 batteries x 2.4 to 2.49 V).

Float-Charge Set Point Voltage. After the absorption period, the charge controller ramps down the charging current to achieve the "float" phase, which is a lower voltage that greatly reduces the batteries' gassing while still keeping the battery full. To continue the example, the float-charge set point voltage range is 2.20 to 2.23 V for each cell. With 12 cells total, the ideal battery bank float-charge voltage set point for this particular battery bank would be between 26.4 and 26.76 V.

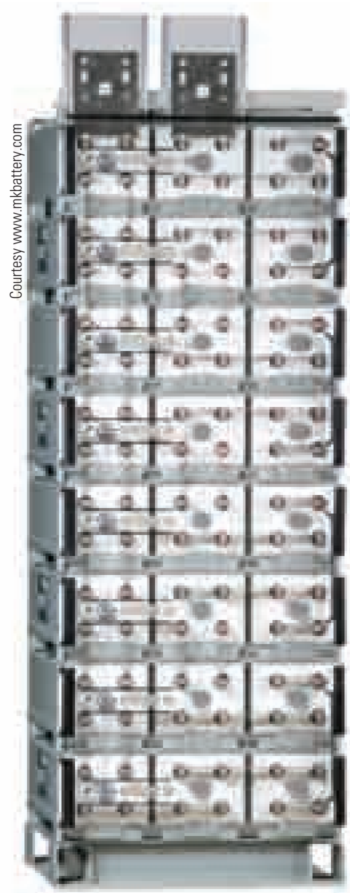
Both AGM and gel-cell batteries will not tolerate voltages that are as high as FLAs. The charge controller's bulk and float set points must be programmed appropriately to avoid damaging these batteries.

Equalization Charge Set Point Voltage. An equalizing charge cycle is a controlled overcharging of the battery bank to make sure all cells get charged, and to remove sulfate ion bonds on the batteries' plates and to regain battery capacity—before permanent bonds develop. First, the battery is charged to full capacity by completing a bulk and absorption charge cycle. Then the battery is charged for an extended period of time, typically 6 to 12 hours, at a C/20 rate (charging amps equal to battery's AH capacity divided by 20). By controlling the charge rate at C/20, the battery is kept from harm. (Uncontrolled overcharging can warp the batteries' plates, causing it to short out and possibly explode.)

Equalizing an FLA battery is essential to maintaining battery life, but can be difficult to achieve with the limited current available from a PV array. In off-grid applications, a backup engine generator is often used to equalize the batteries through a charger. Off grid, the use of household loads is generally limited during equalization to make sure enough current is available. In utility-tied systems with batteries, the grid substitutes for a generator.

Using the example of the four-battery bank (6 V each, wired in series for 24 V) and an equalization charge set point voltage range between 2.5 and 2.67 V per cell, the ideal battery bank equalization charge voltage set point for this particular battery bank would be between 30 and 32.04 V.

It is commonly believed that sealed batteries should never be equalized, yet some sealed battery manufacturers will provide an equalization voltage set point for their batteries. It is important to note that these values are usually the same as the bulk voltage set point for that battery. Typically, equalizing sealed batteries means merely extending the absorption period for a longer duration than normal. Additionally, sealed battery "equalization" is usually done only if the battery is showing signs of



Sealed batteries can be installed on their sides to limit the amount of space required.

Courtesy www.mkbattery.com

Courtesy www.fullriverdcbattery.com

Typical AGM batteries. Left: A sealed FullRiver, similar in dimensions and capacity to a flooded L-16.

Right: Concorde's popular Sun-Xtender battery is about the same size as an automotive starting battery.

Courtesy www.sunextender.com

premature capacity loss (i.e., not lasting as long as normal on a charge), and is not part of routine battery maintenance. Regardless, equalization is very battery specific, so it is important to find appropriate voltage set points and charge current ranges for your particular batteries.

Dimensions. When you're designing your battery bank, the size of the batteries—their length, width, and height—determines the size of the containment that you'll need to buy or build. In addition to considering the dimensions of the batteries, it's a good idea to leave 1/2 to 1 inch of space between each battery. This will help keep the individual batteries operating at the same temperature and allow them to shed heat during heavy charging regimes.

Weight. Even the smallest batteries used in RE systems can weigh as much as a Labrador retriever—50 to 60 pounds. The really big batteries can weigh as much as a small horse. So, adequate trucks, skids, pallet jacks, and forklifts all become more important in moving batteries safely as the bank grows in size. You'll need to make sure your floor and/or rack is stout enough to support the total weight of the bank.

Warranty. Manufacturers generally guarantee their products to be free of defects and perform as specified for a set period of time, and will replace defective units during this time period. Many manufacturers offer one-year free replacement with additional prorated warranties for two or three years. During this period, the distributor will replace the failed unit for a percentage of the replacement cost.

Expected Cycles. Battery life is determined in part by the number of cycles. The more cycles the battery can offer, the longer it will live. But the number of cycles a battery can offer depends on how deeply it is discharged. This is why you see two values listed in this guide for most batteries—the number of cycles offered for 20% or 50% DOD.

A battery listed at 5,000/3,000 cycles will offer 5,000 cycles if it's discharged by only 20%, and 3,000 cycles if it's discharged by 50%. So how many years does this translate into? For off-grid RE, systems are commonly designed to cycle (charge and discharge) once a day, so you can divide the expected cycles by 365 to get a general estimate. In the case of the 3,000/5,000-cycle battery, you could expect a battery life of 8 to 14 years.

However, other factors—like lack of system maintenance, chronically undercharging batteries, or high battery temperatures—can shave years off a battery's lifetime. Discharging a battery deeply and leaving it discharged for extended periods creates sulfation, which blocks the interaction between the acid and the lead, leading to permanent loss of capacity.

Access

Batteries have enabled **Christopher LaForge** (gosolar@cheqnet.net) to live and work for more than 20 years at his off-grid, sun- and wind–powered homestead, SunFarm, in Bayfield County, Wisconsin. He is an ISP-affiliated PV instructor with the MREA, a NABCEP-certified PV installer, and a member of the NABCEP board of directors.

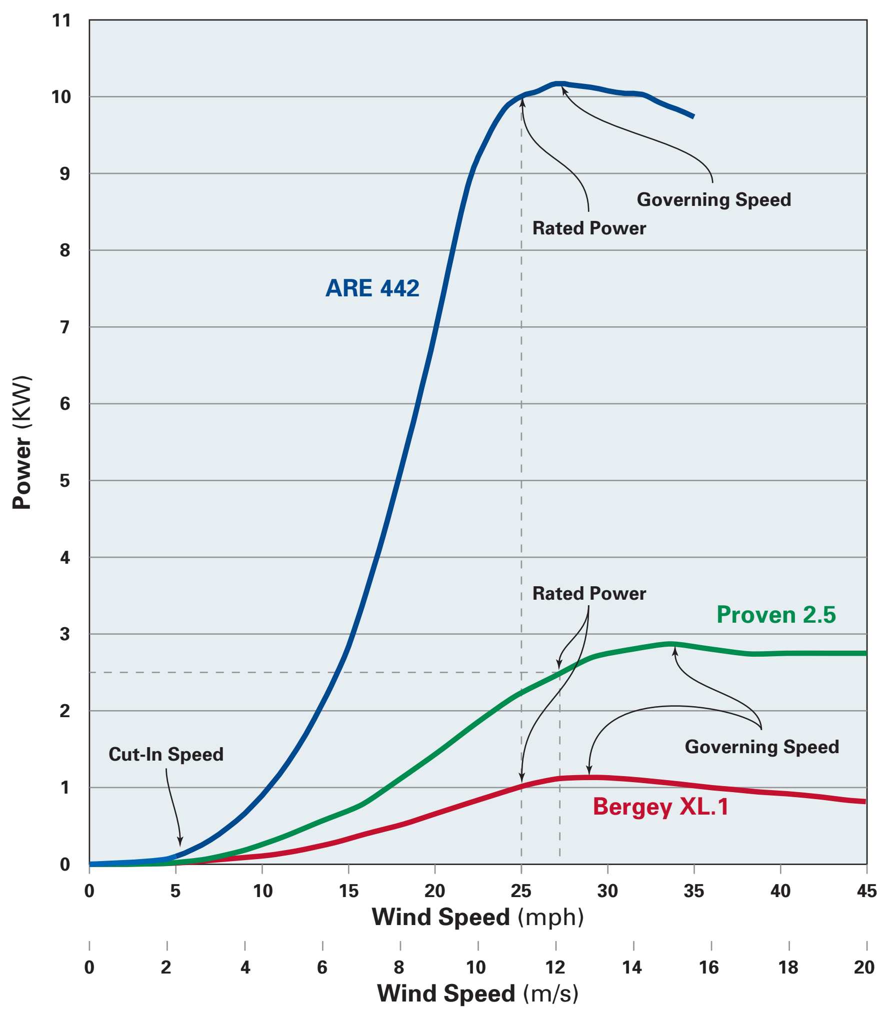
Wind Power Curves

What's Wrong, What's Better

by Ian Woofenden

If you're baffled by a wind turbine's power curve, here's how to interpret wind generator manufacturers' data to choose a turbine that will give you the best performance at your site.

Power Curves for Three Turbines



Power curves are frequently presented by turbine manufacturers in their marketing literature, and interpreting these curves is at best a complicated exercise even for the mathematically inclined. Few wind turbine buyers know how to use this information to determine what they really need to know—how much energy a wind generator will produce at a given site. Let's look at why power curves are not a useful tool for most of us, and what to use instead.

What's the Curve?

Any alternator or generator produces electricity at varying levels, depending on its rotational speed (rpm). When we plot the output against the speed, we get a curve. If the original motive force is wind, we can plot the generator output against wind speed, which gives us what is typically called a "power curve" for the wind generator (see the "Power Curves" graph). It shows wind speed in miles per hour (mph) or meters per second (m/s), and power in kilowatts (KW).

It's important to remember that power in its technical sense means "watts." This is an instantaneous measure of the rate of electricity generation (or transfer or use), and *not* a measure of energy (watt-hours), a quantity.

What's Wrong with the Curve?

Misinterpreting wind generator power curves is common and can happen in a variety of ways. First, the untrained eye is naturally drawn to the top of the curve—the peak power. If we were looking at a gasoline-powered generator, this would be useful information. As long as it's supplied with gasoline and a load, it continues to produce at or near its rated output.

Peak power for a wind generator is very different—at most sites, the wind speed at which a turbine generates its peak power occurs only a very small percentage of the time. So focusing on the peak may lead you to wildly exaggerated energy expectations.

Trying to compare one wind generator to another using power curves is another common mistake. While there is some useful comparative information in the curves, it's not a simple comparison, and people too often scrutinize turbines poorly, looking primarily at the peak. For example, I've lived with two turbines that shared about the same peak on their power curves—yet one produced 2.3 times more energy than the other in similar conditions.

If (and that's a big "if") power curves accurately predicted energy production, it might make sense to compare turbines by looking at the *low* end of the curve. Good performance at low wind speeds is most important in a wind turbine, since that is where it will spend most of its time (see "Wind Speed Distribution" graph).

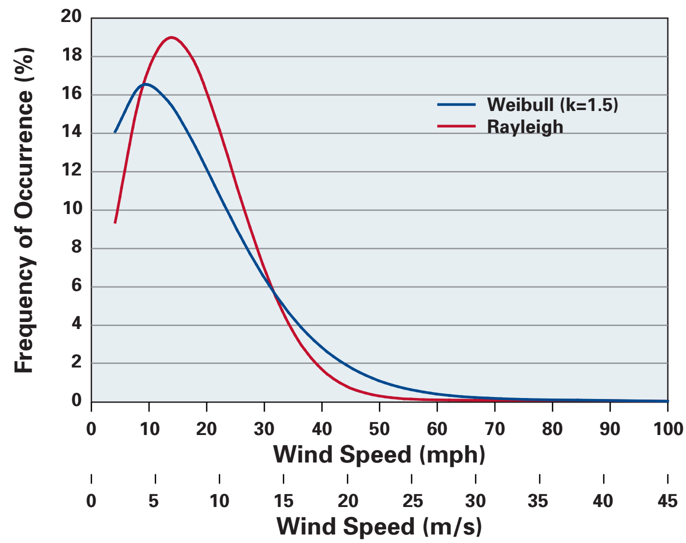
Next, applying an average wind speed to a power curve can be an impossible and illogical task. A power curve demonstrates instantaneous production (watts), while a focus on average wind speed points toward overall energy potential (watt-hours).

All these misconceptions or misunderstandings of power curves become clearer as we look at the physics of wind and the reality of how wind works at a typical site.

Velocity Cubed

Wind is variable. This we know intuitively. We feel it blow lightly on our face one moment, not at all the next moment, and maybe a few minutes later it'll be blowing us down the street. Wind is rarely constant, and it's a myth that there are sites where "it always blows at 15 mph." When you start looking at measured wind data, it's hard to find groups of consecutive data points that are the same in one minute, let alone for hours.

Wind Speed Distribution



The most crucial fact to understand about wind energy is that *the power available in the wind is related to the cube of the wind speed*. Humans are fairly comfortable with linear functions: Spend twice as much money and you'll get twice as much coal; double the rainfall will result in doubling the catchment water into your tank.

Cubic functions are not as intuitive. You might think that when you double the wind speed (velocity, or V), you double the power. But in fact, doubling the wind speed gives eight times the power (2V x 2V x 2V = 8V). A 20 mph wind has eight times the energy (20 x 20 x 20 = 8,000) of a 10 mph wind (10 x 10 x 10 = 1,000). It doesn't always play out precisely this way with wind energy *capture*, since different turbines have different efficiencies. But the principle remains vital to understanding wind electricity.

> "Instantaneous power means nothing for wind energy.
> —Mike Klemen

The V^3 law can be worked both ways—up and down the power curve. If a "perfect" turbine produces 100 watts at 10 mph, it has the potential to produce 800 watts at 20 mph. If the machine produces 1,000 watts at 24 mph, it will produce 125 watts or less in a 12 mph wind. Understanding the V^3 law helps you look at power curves—and wind energy—differently.

Wind Distribution

The other major factor that comes into play is wind distribution. When we start to study the way the wind varies, we find out that every site has a different wind distribution profile. A wind "distribution" plots the frequency of each wind speed. Typically, it's shown in a wind distribution curve (see "Distribution" graph). For example, one site may experience 15 mph winds 4% of the time, and another site may see winds of 15 mph only 3% of the time. The distribution curve

Perfect Turbine or Pipe Dream?

Wind turbines operate within the limits of Betz' Law. Simply put, if you try to capture 100% of the energy available in the wind, the wind is stopped—it cannot move the blades. On the opposite end of the scale, the wind just goes around a fixed obstruction. In either case, the result is the same—no energy is extracted.

The Betz limit says that capturing 59.6% of the energy in the wind is the best compromise between stopping the air and letting it pass through the turbine unaffected. Maintaining the flow of air is the compromise any wind machine must make, whether it is a horizontal-axis (a traditional-style turbine) or a vertical-axis turbine; with many blades or few. All turbines are subject to the Betz limit.

The "Energy Output" table shows the amount of energy you can reasonably capture per rotor swept area at several average wind speeds. You can multiply by the swept area of the turbine you're considering to see if the manufacturer's claims are even possible!

However, comparing the "model" wind turbine columns with manufacturers' claimed production data from four reputable manufacturers' turbines, none are as good as claimed. Numbers in the "Model Turbine" column are based on an average efficiency of 35%. It is not terribly likely that you'll find a wind turbine that is more efficient than this. Remember: If it's too good to be true, it may very well be!

The table shows the energy (KWH) per month that a "perfect" turbine designed to Betz' law could produce, and what a real-world model turbine could produce, taking inefficiencies and design into account. The table assumes a Rayleigh wind distribution at sea level.

Let's try an example. If you have a turbine with a swept area of 10 square feet in a 10 mph wind, you'll find that the "model" turbine value per square foot of rotor is 2.08. Multiply it by 10 because you have 10 square feet of rotor. If the manufacturer is claiming that the turbine can put out *more* than 20.8 KWH per month, the turbine is probably too good to be true. Next, multiply the Betz limit value of 3.5 by 10. If the manufacturer claims you can generate more than 35 KWH per month, then they are claiming to have broken the laws of physics.

—Mike Klemen

Monthly Energy Output Per Sq. Ft. of Swept Area

Average Wind Speed		KWH Per Month	
MPH	Meters Per Sec.	Betz Limit	"Model" Turbine*
5	2.2	0.42	0.25
6	2.7	0.74	0.44
7	3.1	1.21	0.72
8	3.6	1.83	1.08
9	4.0	2.60	1.55
10	4.5	3.50	2.08
11	4.9	4.46	2.64
12	5.4	5.38	3.19
13	5.8	6.23	3.69
14	6.3	6.94	4.12

*Based on 35% turbine efficiency

shows what percentage a given site experiences at each wind speed.

Because of the V^3 law, the specific wind distribution can theoretically have a pronounced effect on energy capture at a particular site. To cite an extreme and theoretical example, let's examine two sites: one that experienced 10 mph winds for four weeks straight, and another site that had 40 mph winds for one week and no winds (0 mph) for three weeks.

Both of these fictional sites have a 10 mph average, but the wind distribution is very different indeed. If we apply the V^3 law, the first site has 10 x 10 x 10 = 1,000 units x 4 weeks, or 4,000 units. The second site has 40 x 40 x 40 = 64,000 x 1 week plus 0 x 0 x 0 = 0 units x 3 weeks, for a grand total of 64,000 units. What a difference! What good is an average wind speed on its own, if the distribution makes the available energy vary that much?

In the real world, wind distributions don't vary as widely as this extreme example, and in fact tend to be quite similar in most locations where we site wind turbines. In North America and Europe, there's a fairly predictable wind distribution. Standardized distributions (such as the Rayleigh in the Weibull family of distributions; see graph) correspond fairly well with the reality on these continents. Utility-scale wind farm developers rely on very detailed distribution profiles for each site. For home-scale wind-electric systems in most places, it's safe to use the standard distributions that turbine manufacturers assume in their energy predictions. Energy availability doesn't typically vary more than about 25% from site to site.

Value of Power Curves

Power curves do have a couple of concrete applications. First and foremost is that they show you at what wind speed a turbine will govern. "Governing" is the means of controlling the machine in high winds. According to the cube law, the forces on a wind generator in storm winds are enormous and potentially destructive, and the last thing you want your wind turbine to do is to try to capture them! For instance, an 80 mph wind would equal 512,000 units (80 x

80 x 80). You'll want to keep your turbine out of that kind of wind's way (perhaps while still generating a bit of energy) so it can stay intact for the next reasonable wind.

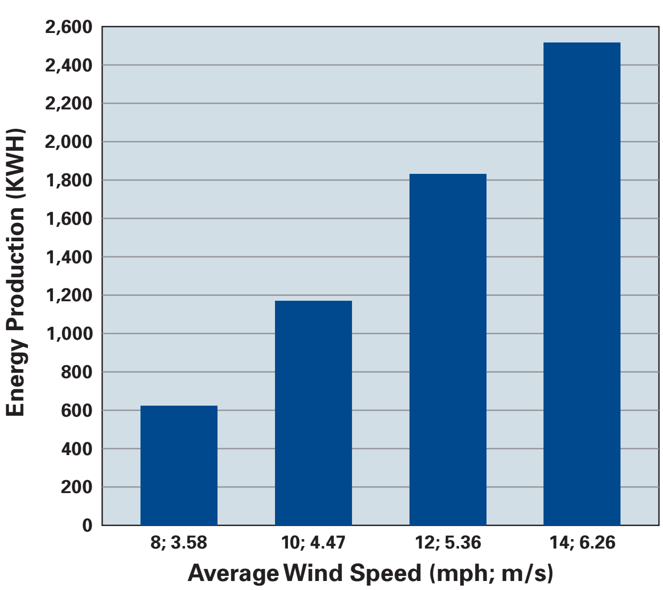
By looking at a power curve, you can see what a turbine does (or supposedly does) in high winds. If the curve keeps increasing above about 30 to 35 mph, don't buy it! Few turbines can withstand the forces of storms if their rotor has to take the full brunt of storm winds. Long-time wind-turbine tester Mike Klemen of Harwood, North Dakota, says, "Any turbine that doesn't protect itself well dies here. I will never buy a turbine without seeing a power curve that proves that the turbine protects itself." Perhaps we should rename power curves "governing curves," so wind turbine shoppers understand the main value of the curve.

The other value in power curves is to electrical designers who create the other components needed in wind-electric systems. Knowing the cut-in point, peak voltage and current, and what's in between is necessary to specify appropriate components, and design robust controllers and inverters to match the generating characteristics of a wind turbine.

Energy is the Goal

The bottom line is that power curves are primarily an esoteric measure for wind geeks, with the unfortunate consequence of creating much confusion about wind generator performance. When we buy a car, most of us don't look at the horsepower of the engine or the cold cranking amps of the battery. We turn to more important overall measures like fuel economy. So we should leave power curves to the number nerds, and stop distracting ourselves from the prize—energy output. But what's an average wind system shopper to do?

Annual Production Estimates* for ARE 442



*Based on a Rayleigh distribution

Veteran wind-energy expert Hugh Piggott says, "The power curve on its own doesn't tell you anything about energy, nor is there any simple way to determine that from a given power curve." We don't buy watts from the utility, and we don't put watts into our battery bank or into the grid. We buy, produce, and sell *watt-hours*—energy. So we should evaluate wind machines based on their energy performance, not peak power, or any other single point on the power curve.

Instead of using power curves, look on the manufacturers' Web sites or in their literature for *energy* curves or graphs (see the ARE 442 example). With an estimate or measurement of the average wind speed at your site, these curves can help you project the energy yield from a particular turbine. Then you can determine how that projection matches up with your energy needs, and get on with the job of designing and installing your wind-electric system.

Understanding power curves and energy curves can help you sort fact from hype, and real products from scams. See the "Perfect Turbine or Pipe Dream?" sidebar for how to do a reality check on the manufacturers' or promoters' claims. In addition, search the Internet for real-world users of the turbine you're considering, and compare the manufacturers' claims to reports of actual system performance.

Whether you are sizing a system or evaluating a product, you'll be working with an *estimated* average wind speed and an *estimated* energy production curve. That means that your numbers will be rough guesses at best. Get used to it—with small-scale wind systems, it is rarely practical or affordable to do much better than this. So be conservative when you design, and with luck, you'll be pleasantly surprised at your turbine's actual energy performance.

Access

Ian Woofenden (ian.woofenden@homepower.com) devotes time to debunking wind myths at his wind- and solar-powered home in Washington's San Juan Islands.

Thanks to Mike Klemen (www.ndsu.nodak.edu/ndsu/klemen) and Hugh Piggot (www.scoraigwind.com).

Solar-Electric Options: Crystalline vs. Thin-Film

by Erika Weliczko

Options for residential solar-electric modules used to be nearly as limited as the choices Henry Ford offered when his Model Ts first rolled off the line. But times have changed, and so have the choices in PV technology. Now, besides conventional aluminum-framed and glass-topped single- or multicrystalline PV, consumers can choose from thin-film PV in frames or building-integrated products like metal roof laminates.

But what's best for your situation depends on a variety of factors, including budget, space limitations, and climate. Here's a rundown of the choices, and how to find the best technology to suit your needs.

The flexibility of thin film PV modules makes them great for many uses, but they're not necessarily the best choice for residential-scale systems.

Courtesy www.nrel.gov

Two Technologies

If you were to place a crystalline module beside a thin-film module, some differences will be more apparent than others. The first distinction is appearance. Single-crystal PV modules have distinct, dark-colored cells that are either rectangular or octagonal in shape; multicrystalline modules have some sparkle to the cells, and are usually rectangular. In each, the electrical connections are evident as a regular pattern of parallel, silver lines called traces.

"Thin-film" is used somewhat as a catch-all phrase, since it refers to a variety of module compositions, including amorphous silicon (a-Si), cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS). One of the main advantages to amorphous silicon is that it can be directly deposited on glass or even plastic, allowing it to be manufactured in long, continuous rolls, or incorporated onto a flexible substrate, such as laminates, shingles, and roofing tiles—even backpacks. The appearance of amorphous silicon also tends to be more uniform. Because of the uniform color, thin-film products appeal to those with a major concern for aesthetics—architects, designers, and end users—for streamlined building-integrated applications.

But where the differences between the two module types really show up is in their sunlight-to-electricity conversion efficiencies and power densities. Crystalline modules require less space than thin-film modules for the same amount of power—thin-film is less efficient in the conversion of sunlight to electricity.

Single- and multicrystalline modules have typical conversion efficiencies between 12% and 17%. But thin-film technologies can have half that, ranging from 6% to 8%. Thin-film modules take up about twice as much space to generate an equivalent amount of energy compared to crystalline modules.

Sizing Systems

Let's take a look at how this difference influences PV system sizing. For a utility-interactive PV system, a typical crystalline module would be 170 to 220 W (STC), have an efficiency between 12% and 17%, and measure approximately 3 by 5

feet. An amorphous thin-film module might deliver between 60 and 70 W (STC) with an efficiency between 6% and 8%, and measure about 3 by 3 feet.

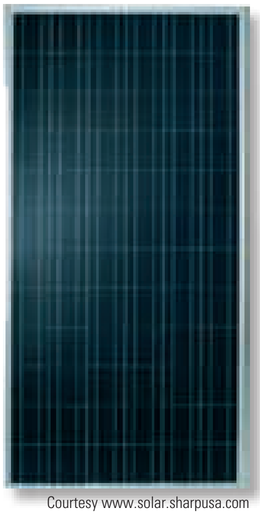
Besides power density, there are two key differences in performance between crystalline and thin-film technologies. The first is impact of cell temperature on power production. The second is initial module power stabilization.

All PV modules experience a reduction in power with increasing cell temperature. For example, at 100°F, our sample crystalline module will produce approximately 6% less power than its STC rating. This effect is less pronounced for thin-film PV technologies—our example a-Si thin-film module would produce only 2% less power. While you can reduce cell temperature by allowing adequate air flow around any module, PV cells sitting out in the sun will still get hot—so thin-film a-Si modules might be a good choice for warm climates, especially if there's plenty of room for the larger array.

The Sharp multicrystalline module (right) is 14 sq. ft. and rated at 170 W, over 12 W per sq. ft.

The Kaneka a-Si module (below) is about 10.2 sq. ft. and rated at 60 W, under 6 W per sq. ft.

Courtesy www.sunwize.com



Courtesy www.solar.sharpusa.com

Crystalline vs. Thin-Film PV Technologies

Module Characteristics	Sharp Crystalline	Kaneka a-Si
STC power (W)	170	60
PTC power (W)	150	56
Dimensions (in.)	32.5 x 62.0	37.8 x 39.0
Module efficiency	13.1%	6.3%
Power density (W per sq. ft.)	12.13	5.87
Open circuit voltage (Voc)	43.2	91.8
Operating voltage (Vmp)	34.8	67
Number of modules in series at -25°F for under 600 VDC	11	5
Operating current (Imp)	4.9	0.9
Temperature coefficient of voltage (per °C)	-144 mV	-0.31%
Temperature coefficient of power (% per °C)	-0.49%	-0.19%
Cost per module	$1,029	$339
Cost per watt	$6.05	$5.65
Color	Dark blue	Maroon
Warranty (yrs. @ % of rated power)	10 @ 90%, 25 @ 80%	25 @ 80%

3 KW System Characteristics

Array STC power (W)	3,060	3,120
Number of modules	18	52
Area required (sq. ft.)	259	550
Mounting rail length (ft.)	102	345
Module electrical arrangement	2 strings of 9 modules	13 strings of 4 modules
Module physical arrangement	2 rows of 9, portrait	4 rows of 13, landscape
Array Vmp	313.20	268.00
Array Voc at -20°F	458.65	428.56
Array Vmp at 100°F	296.61	257.37
Est. retail equipment cost, all equipment & materials	$24,500	$31,000
Est. system installation cost, complete	$3,400	$4,600

Amorphous silicon modules take 6 to 12 months to reach their stable, rated output, whereas crystalline modules stabilize right away. So a-Si modules will show 20% to 25% higher-than-rated production at first. While that sounds like a bonus, this initial additional output must be considered in system design (for selecting wire sizes, charge controllers, and inverters). For example, if the final design indicates a 15 A circuit, the initial extra output might require accommodating 20 A. After this stabilization, thin-film modules degrade at similar rates to crystalline, about 0.5% to 1.0% per year.

Some thin-film technologies provide better shade tolerance and low-light performance than crystalline modules. For example, Uni-Solar products are flexible and made with triple junction a-Si cells. The flexibility allows the use of bypass diodes across each cell within the module (not just within the module junction box), allowing current to flow around any shaded cell. And each "sub-cell" of the multi-junction cell can capture different light wavelengths, resulting in higher power production in cloudy weather and diffuse light. Other thin-film modules (without bypass diodes on every cell) have better shade tolerance than crystalline modules due to cell shape. Many thin-film cells are as long as the module itself, so shading an entire cell is more difficult than the traditional 5- or 6-inch square or round crystalline PV cell.

Other Considerations

When selecting an inverter, the voltage extremes of the array should be within the maximums of the inverter. Most thin-film modules have high voltages and low current. To keep voltages of batteryless systems below 600 VDC to meet *National Electrical Code* requirements, a higher voltage means fewer modules in series. Some inverters have optimal voltage ranges that span as little as 150 VDC, making it challenging to design arrays with thin-film modules that have open-circuit voltages approaching 100 VDC.

Battery charging PV systems have different voltage requirements. Historically, nominal PV array voltage would


Courtesy www.nrel.gov

Building-integrated PV products, like these roof tiles, can be made with crystalline PV cells, for an aesthetic look that requires less roof space than thin-film products.

PV Technology & Efficiency

have to match nominal battery voltage. However, with the advent of step-down charge controllers, up to three 24 V nominal modules in series can be used in some climates to charge a 12, 24, or 48 V battery bank. Using the same step-down MPPT charge controller, one high-voltage, thin-film module can be paralleled with its neighbors. Battery-charging systems with thin-film arrays will almost always require an MPPT controller with step-down functionality.

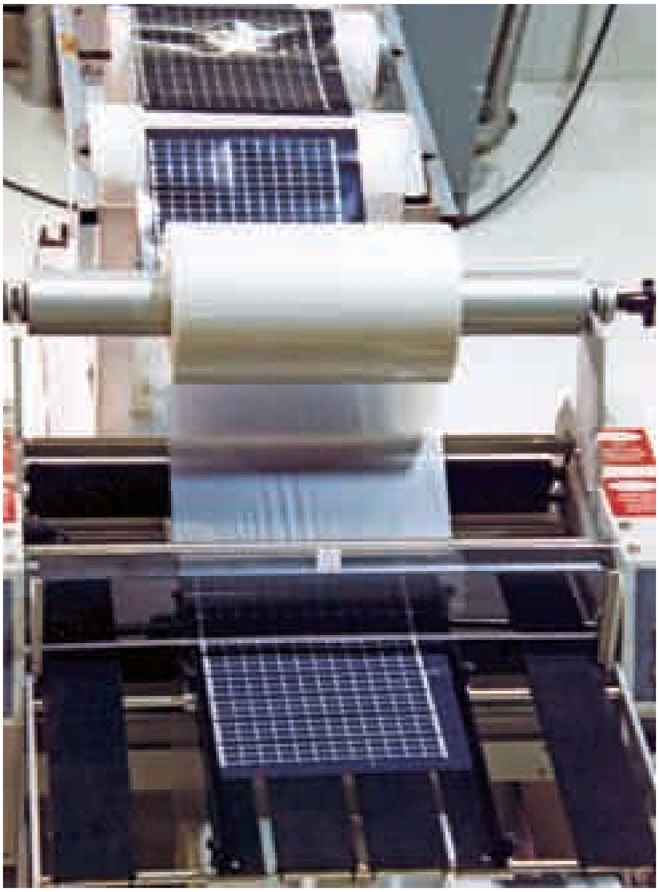
Comparing Costs

While the use of less material and energy during the manufacturing of thin-film modules creates a product that is less expensive per watt, the additional hardware and equipment costs usually increase the overall installation costs. As a result of the physical and electrical differences, California's Sacramento Municipal Utility District estimated that amorphous silicon modules needed to be $0.50 to $0.80 per watt cheaper than crystalline modules in order to be competitive.

To help get a handle on the differences between crystalline and thin-film, let's compare two 3 KW nominal systems (see comparison table). Assume that both are grid-interactive, batteryless systems with modules mounted on a roof in a rectangular arrangement using top-clamping racks. The racks support the modules, with two rails underneath each row, and four clamps secure each module to its rails.

Besides the basic equipment differences, installation differences emerge as well. If the crystalline modules use 102 feet of rail, this means locating and installing 40 mounting feet and lag bolts on the roof (assuming attachment points are installed every 32 inches). The 345 feet of rail required for the thin-film array would require triple that—129 attachment points. Additionally, since there are nearly three times the number of modules, installation of the modules and the clamps between them might take two to three times as long,

Thin-film modules don't necessarily need glass. Flexible plastic substrates and laminated coatings can keep them light and flexible—perfect for low-power, portable needs.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Crystalline & Thin-Film Advantages & Disadvantages

Advantages

Crystalline Silicon	a-Si Thin-Film
Highest power per area	Output less affected by temperature
Requires less racking & support material	Less manufacturing materials used
Fewer modules means lower shipping costs	Lower cost per watt
Large number of module choices	Good aesthetics for building-integrated applications
Greatest inverter flexibility	Less embodied energy (faster energy payback)
	Non-glass substrates possible
	More shade tolerant

Disadvantages

Crystalline Silicon	a-Si Thin-Film
Higher cost per watt	Lower power per area
High temperatures affect output more	Takes months to stabilize output
Low shade tolerance	Twice as much rack material required
Individual cell visibility	More modules mean higher shipping costs
	Lower series-string capacity
	Less suitable for battery charging
	Requires more combiner boxes
	Limited inverter flexibility
	Fewer module manufacturer choices

meaning higher installation costs. With a greater number of series strings, the conduit, wire, and additional labor necessary to get from the array to the combiner boxes is an expense that is not necessary for the crystalline array. The higher initial output of the thin-film array needs to be accounted for, which may translate into having to use a larger wire gauge and increased wire expense.

When considering the additional equipment, shipping, and labor next to the reduced module price, choosing the thin-film array increases costs by as much as $1.50 to $2.50 per watt. Is it worth it? It depends. Given site specifics like temperature and cloud cover, will the a-Si modules be 10% to 20% more productive? Thin-film manufacturers will say, "Of course!" And testing conducted in warm and sunny climates, as well as cooler and cloudier, has shown that a-Si modules typically produce slightly more KWH per peak KW capacity. The "Advantages & Disadvantages" table will help you compare and contrast the key features of each, so you can choose the best technology for your application.

Payback

As a result of using far less materials, the embodied energy of thin-film products is significantly less than crystalline products. The National Renewable Energy Laboratory reports that the energy payback time for thin-film PV technologies is about one-half that of crystalline modules. A thin-film module creates enough electricity in operation to offset its embodied energy within 1.5 years compared to within 3 years for crystalline modules (see "PV Energy Payback" article in this issue).

Access

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Sources:

"Overview Of Amorphous Silicon (a-Si) Photovoltaic Installations At SMUD," Spectrum Energy • www.nrel.gov/pv/thin_film/docs/osborn_ases_smud_asi_experience.pdf

"Thin Film Solar Cells and United Solar (Uni-Solar) Amorphous Silicon Vapor Deposit Panel Manufacturing Technique" • www.solarnavigator.net/thin_film_solar_cells.htm

"Kaneka Module Specifications & Design Guidelines," Sunwize • www.sunwize.com/info_center/pdfs/Kaneka%20Design%20Guidelines%20112907.pdf

"Performance and Reliability of a 1-KW Amorphous Silicon Photovoltaic Roofing System," NREL • www.nrel.gov/docs/fy05osti/36583.pdf

Thin-Film Manufacturers:
Global Solar • www.globalsolar.com
Kaneka • www.kaneka.com
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SunPower • www.sunpowercorp.com
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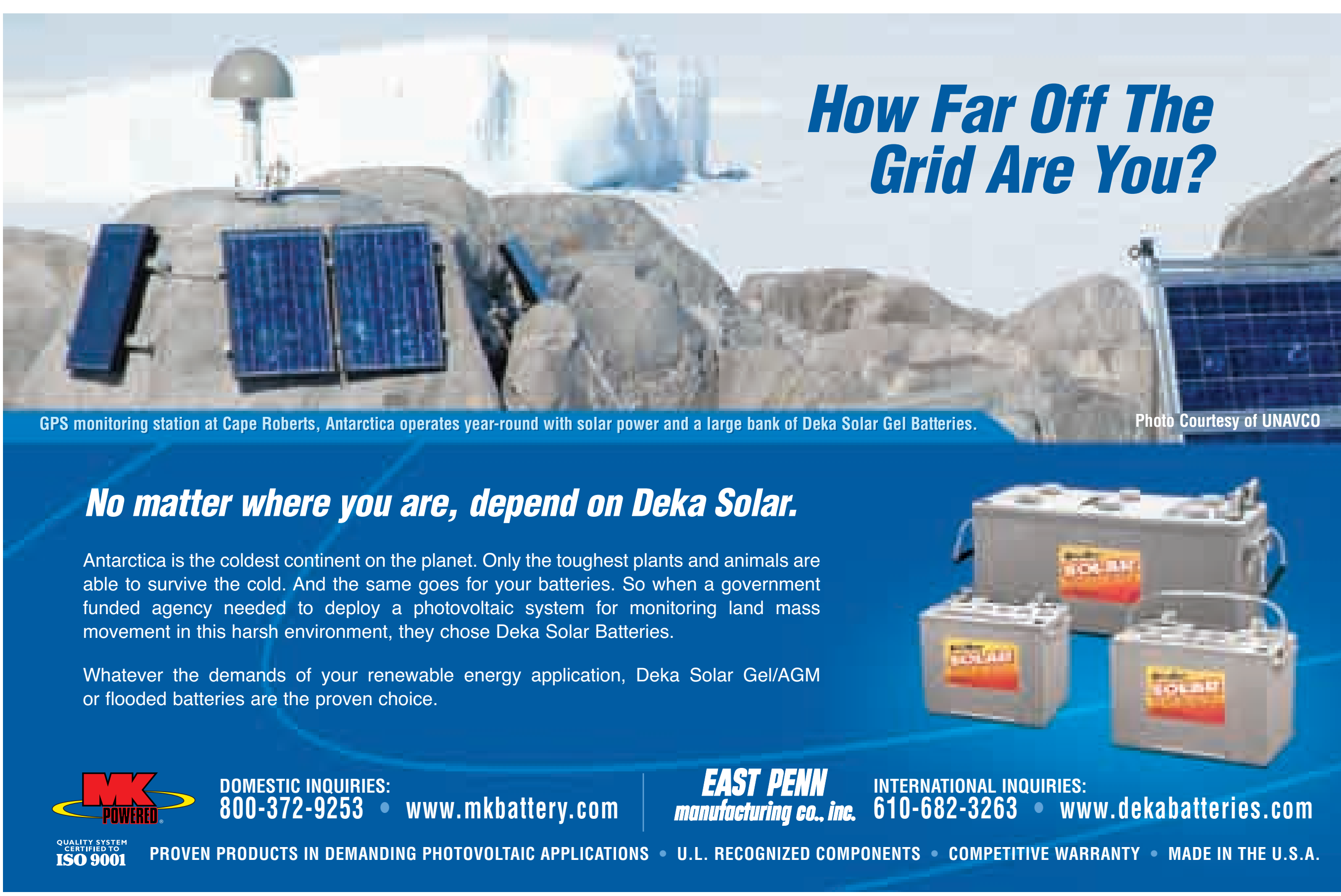
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New Grounding Methods

NEC Compliant or Not?

by John Wiles

PV modules and racks must all be properly grounded.

Many photovoltaic (PV) systems will be producing hazardous voltages and currents for 50 years or more. During that period of time, they may or may not be operational, and they may or may not be maintained. That's why it's important to properly ground all the system's exposed metal surfaces that may be energized by internal faults, poor terminations, or failing conductor insulation. Even in a failed system, maintaining all metal surfaces at ground (or earth) potential will minimize the possibility of electrical shocks.

What's the Problem?

Heating, ventilation, and air conditioning (HVAC) systems are exposed to the same environmental conditions as PV systems, but there are significant differences in the grounding requirements and procedures between the two systems. Yet comparisons between the two systems are sometimes drawn by PV installers.

PV modules, with a life measured in decades, will typically be in place longer than the outdoor unit of a HVAC system. When the performance of an HVAC system deteriorates, it is usually inspected and repaired promptly. PV systems suffer gradual degradation that is often not monitored, and the PV array may remain installed on the roof even after the system is no longer being used.

Although HVAC units have only a few separate pieces, the equipment grounding points are well marked, and the factory-installed bonding jumpers and screws effectively bond all parts of the listed device together. HVAC components are typically made of steel, and the equipment-grounding terminals are electrically and chemically compatible with copper conductors.

On the other hand, PV systems have numerous modules (tens to thousands) and mounting racks that all must be properly grounded. PV modules and mounting racks are

typically made of aluminum and are *not* compatible with copper conductors. (See Access for more information on grounding aluminum-framed PV modules.)

Getting Grounded

Electrical inspectors have been communicating with Underwriters Laboratories (UL) about poor PV module and PV system grounding techniques and equipment that they are seeing in the field. As a result, UL is getting tough on grounding. In the fall of 2007, UL issued an "interpretation" of the existing standard (UL 1703) for PV modules. The grounding problem is in part due to a confusing section in UL 1703 that discusses bonding requirements and instructions (connecting the module frame parts together in the factory) as well as grounding requirements (installing the external equipment-grounding connection in the field). Methods and equipment used in the factory to bond the module frame sections together are evaluated during the listing process. However, the same level of scrutiny cannot be applied to field-installed, equipment-grounding methods, and the same parts and techniques used in the factory are generally not appropriate in the field.

UL's interpretation clarifies the intent of the standard in several areas:

- Dissimilar metals, like copper and aluminum, cannot come into contact with one another at the equipment-grounding connection point. UL provides a chart showing numerous metals and which types can be in contact without galvanic corrosion problems.
- Any threaded fastener used for grounding must pass the same durability tests as any threaded fastener used for other electrical connections. It must be fastened and unfastened ten times without damage to the threads on any part. This requirement will probably result in the demise of using thread-cutting or thread-forming screws for module grounding because screwing them into soft aluminum typically cannot meet this requirement.
- The module manufacturer must provide or designate the specific hardware and methods used to ground the module, and those instructions must be included in the module installation manual. UL will evaluate the grounding hardware and methods throughout the entire testing and listing/certification process on new modules and when existing modules come up for recertification.

UL is also working on changes to UL 1703 that will clarify the requirements, markings, and instructions for grounding PV modules. At some point, they will develop a separate standard that will allow the evaluation and listing of various universal PV module grounding methods and devices that will work with a number of different module frame geometries. The use of this standard will allow grounding-device manufacturers to meet the standard without having to be tested with each and every type of PV module.

As the Code requires, instructions and labels provided with a certified/listed product must be followed (110.3(B)). But the listing and certification process is slow, and modules only come up for review every five years. Therefore, it may be some time before all of the instruction manuals meet the clarified intent of UL 1703.

HVAC grounding is not to be compared with PV system grounding.

New Grounding Devices

With respect to new PV module grounding methods and devices, such as clips and washers, the situation is somewhat murky. Of course, the local authority having jurisdiction (AHJ) can call it as they see it, and some jurisdictions have accepted these new devices.

As mentioned, *NEC* Section 110.3(B) requires that the instructions and labels provided with a listed product be followed. PV modules are marked for grounding at specific points. Hardware (when provided) and these instructions require the use of the marked points. The instructions do not generally address grounding the module at the mounting holes or at other locations.

A few manufacturers may provide tech bulletins that show other methods. These tech bulletins may or may not have been reviewed by UL where they differ from the listed grounding points. UL is attempting to review new manuals and directions submitted by the manufacturer, but at times, the manuals get published without UL review. Also, even if reviewed, they may not be in compliance with all *NEC* requirements or may show grounding techniques that have not withstood the test of time. The future UL Standard for PV Module Grounding Methods/Devices will evaluate the long-term durability and reliability of the various grounding methods and devices.

When using a new grounding method, other than running a separate grounding wire to each PV module, grounding continuity must be addressed. One of the oldest requirements in the *NEC* is to make a grounding connection first and break it last (250.124(A)). Consider a module with an internal ground fault or leakage currents to the frame. If the circuit conductors are left connected and the module is unbolted from the grounded rack (disconnecting the frame grounding

PV modules do occasionally fail and may create hazardous fault conditions in poorly grounded arrays.

first rather than last), the module frame may be energized—providing up to 600 volts between the frame and the grounded rack. Ground-fault protection systems will not respond to ground faults and leakage currents less than about 0.5 amps (they are anti-fire devices, not anti-shock), and only the first ground fault is interrupted when they activate.

A few PV systems integrators have a listed combination—listing the PV modules they use along with proprietary grounding devices and racks. Rack manufacturers also are developing grounding devices, but they are not associated or listed with any particular module at the present time.

See Appendix G in the latest version (1.8) of the *PV/NEC Suggested Practices Manual* for the grounding method we currently use at the Southwest Technology Development Institute. This method can be used only if it does not conflict with the module instructions and when those instructions allow the use of a properly listed lug attached to the marked grounding points after appropriate surface preparation.

I have long encouraged module manufacturers to get their modules tested with new grounding products and integrate that information into the instruction manuals to help ensure a code-compliant installation that doesn't cause headaches for AHJs. Section 690.43 of the *2008 NEC* allows the use of these new devices as soon as they have been listed/certified and identified for that use in the module instruction manuals.

A related question that will eventually have to be addressed is: To what are these new grounding devices attached? It is necessary to first verify that they can make a durable connection with the module frame. Then the device must make a connection to an acceptable grounding electrode (such as building steel) or to an accepted equipment-grounding conductor such as a copper conductor. Aluminum module mounting racks are not currently listed as equipment-grounding conductors, but some of the rack manufacturers are in the process of obtaining such a certification/listing. This is necessary because the racks are typically designed for mechanical durability and not electrical connections. Joints may be designed to allow for thermal expansion and contraction, and with aluminum, such "slop" does not make a good electrical connection. For loosely jointed metal raceways, *NEC* Section 250.98 requires that a provision for electrically bonding the sections of the rack together must be incorporated into the design.

Grounding the Future

In the future, modules will either come with an integral mounting rack (there are a few now) or they will be easily attached to a rack providing robust mechanical and electrical connections. One point on the rack will allow for the connection of the equipment-grounding conductor for all modules and for a grounding conductor routed directly to earth (where required). Installations will take less time, cost less, and will keep those module metal surfaces grounded til the cows come home.

Access

John Wiles (jwiles@nmsu.edu) works at the Institute for Energy and the Environment, which provides engineering support to the PV industry and a focal point for code issues related to PV systems. As a solar pioneer, he lived for 16 years in a stand-alone PV-powered home—permitted and inspected, of course. He now has a 5 KW grid-tied system with whole-house battery backup. This work was supported by the United States Department of Energy under contract DE-FC 36-05-G015149.

Photovoltaic Power Systems and the 2005 National Electrical Code: Suggested Practices by John Wiles • www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/PVnecSugPract.html

PV Systems Inspector/Installer Checklist and previous "Code Corner" articles • www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/Codes-Stds.html

"PV Array Grounding," *Code Corner, HP102 & HP103* • Grounding aluminum-framed modules


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Extra Credits

The Need For An Even Playing Field

by Michael Welch

In a perfect world, there would be no need for renewable energy tax credits, installation incentives, R&D grants, and other government subsidies. Generation resources and technologies would be carbon- and environmentally-neutral, and readily available to everyone. Individuals would have complete control over their energy destiny, and every type of energy production would be without governmental support.

But we are far from that perfect world. And even farther from having a true democracy—a country run by its populace. Today, our government, in large part, is run under the tremendous influence of corporations. In the history of politics, this is a fairly new phenomena—many are starting to call our form of government a corpocracy or a corporatocracy, because influence over lawmaking and regulation has been transferred out of the hands of the public. Up to now, a plutocracy—government that is run by the wealthy few—has been the closest model to this.

Unlike other forms of government that are run by or through the populace, wealthy or not, a corpocracy is effectively managed by soulless corporations. Our own government fits that bill because it is primarily motivated or influenced, if not run, through businesses whose overriding interest is profit. Those influences come from huge financial gifts that have become the hallmark of political campaigns, and from the use of high-priced professional lobbyists who gain access to our politicians and government regulators—neither of which are tools available to most citizens.

The larger and more powerful the corporation, the more influence they can exert. Over the years, the largest and most powerful of these corporations have made their multi-trillions of dollars by exploiting the extractable resources, environmental quality, and human resources of the United States. As local resources have dwindled and become more expensive, their reach has expanded to the rest of the world. For example, now that our country's oil supplies are almost depleted, gaining control over Mideastern oil supplies has become an overriding corporate/government goal, to the tune of $341.4 million per day for the war in Iraq.

Cash Cow

The use of tax dollars in the form of direct subsidies, and laws that give advantages despite environmental and health consequences, has helped support many types of industries—even those that are already profitable. Where nonrenewable energy corporations are concerned, these subsidies have included everything from dirt-cheap rights to extract resources from public lands, to using public money for research and development (R&D) that helps them develop more products and extract even more resources—which will ultimately result in more profits. Globally, more than $200 billion a year in subsidies are given to conventional energy industries, making it very hard for RE to compete. These companies spend a little of their profits—which translates to a lot of money for politicians—on influencing government and are able to reap benefits far beyond these expenses.

This is what the still-budding RE industries are up against—a system that heavily rewards large, mature energy industries. RE industries are surviving despite this, because of their tenacity and because of a growing awareness of the need for RE technologies. They crawl along without strong support (globally, less than 5% of what mature, conventional energy technologies receive), yet thrive on their own merits, trying to move up from the grassroots level to their deserved position.

Redistribute Corporate Welfare

This leaves the RE industry and its grassroots support two options: continue slow growth relative to mainstream technologies, or figure out how to play ball in the big leagues with the mature, "conventional energy" corporations.

Thus, the RE industry recognizes the need to fight for a share of the tax dollar pie, as despicable as that might seem to many of us. As the industry slowly grows, it gains in influence to increase its share of corporate welfare. With any luck, and lots of hard work, the playing field will be equalized in time to avoid an environmental breaking point.

The use of tax dollars for private R&D and to increase market share and industry profits is far less than ideal. But what else can the RE industry do to compete in a nation that is largely controlled by corporate interests? Sure, we can and should fight corporate welfare from our governments, and we should each do the best we can to take personal responsibility and by using RE in our own lives and promoting RE technologies. But if we do not organize and grow RE industry efforts to compete, our nation will be forever stuck with the deadly industries—coal, oil, natural gas, and nuclear—that make up the most powerful and influential of energy industries. The U.S. oil industry continues to post record profits, yet earlier this year they went to Congress to request $1.8 billion in tax credits per year over the next ten years.

What To Do

First and foremost, we must continue our struggle to even the playing field between the conventional, dirty energy technologies and renewable energy. That includes fighting for subsidies and incentives for the RE industry. At the same time, we must decry and fight subsidies for polluting technologies. Politicians and bureaucrats still seem willing to bend an ear to their noncorporate constituents, but they will not be forced to act on our behalf until they hear from enough of us to overcome the din of corporate influence.

Support large organizations that are on the RE front, like the American Solar Energy Society, the American Wind Energy Association, the Solar Energy Industries Association, Greenpeace, Nuclear Information and Resource Service, Beyond Nuclear, Earthjustice, and Public Citizen. And just as important, support your local groups (and candidates) that are tackling issues of energy, human-caused climate change, and corporate welfare. All these organizations are working hard to gain an even playing field for the energy industry sector, and to put an end to polluting technologies.

Vote for candidates who are not beholden to corporations, and those who support RE. A vote for mainstream candidates is a vote for the status quo—leaving us in the grip of corporate political power and the conventional energy magnates. There are qualified, anticorporate candidates running in many elections—including the upcoming presidential race. Seek them out, and reward them with your vote.

I hold out much hope that we can wrestle our nation from the bonds of corpocracy and back into its intended state of democracy. Toward that goal, we must fight the notion of corporate personhood which, via interpretations of a U.S. Supreme Court decision dating back to the mid-1800s, has slowly eroded the distinctions between corporate "citizens" and natural citizens—another uneven playing field.

Once we have won back our nation from the stranglehold of corporate personhood, then and only then should we cease asking for subsidies to help out our renewable energy industries.

Access

Michael Welch (michael.welch@homepower.com) has been working for a clean, safe, and just energy future since 1978 as a volunteer for Redwood Alliance and with *Home Power* magazine since 1990. His own grassroots efforts have helped grow the RE industry, and he looks forward to more rapid RE industry growth.


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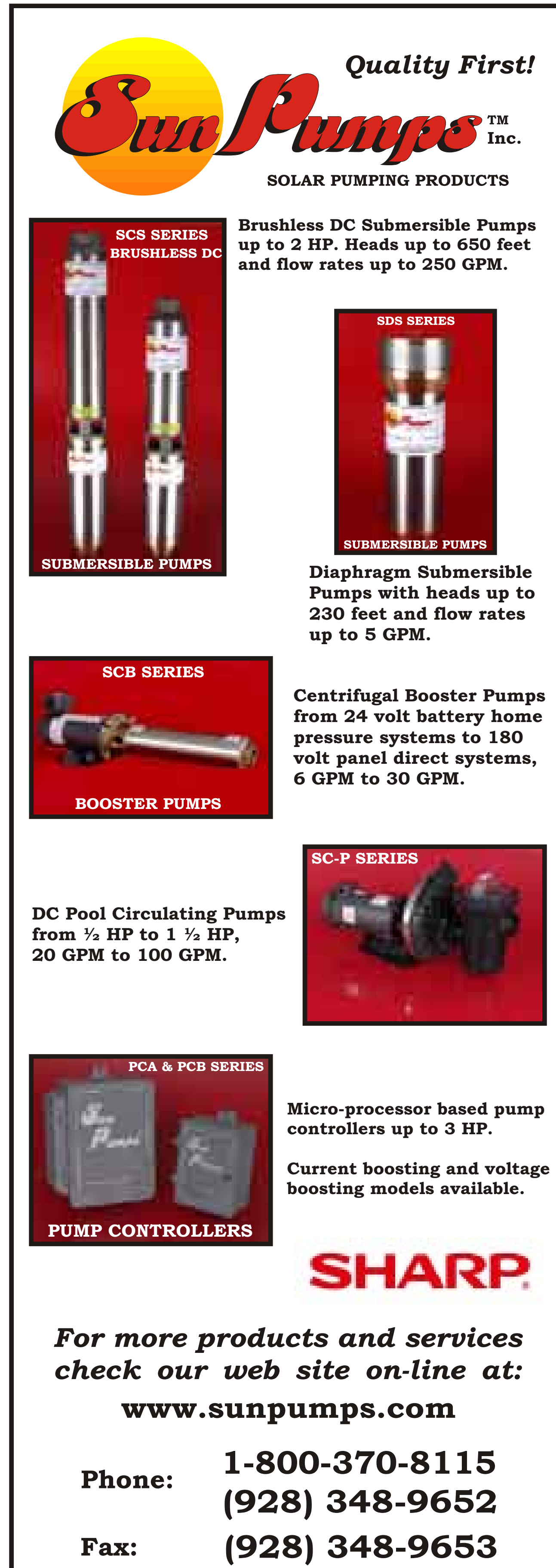
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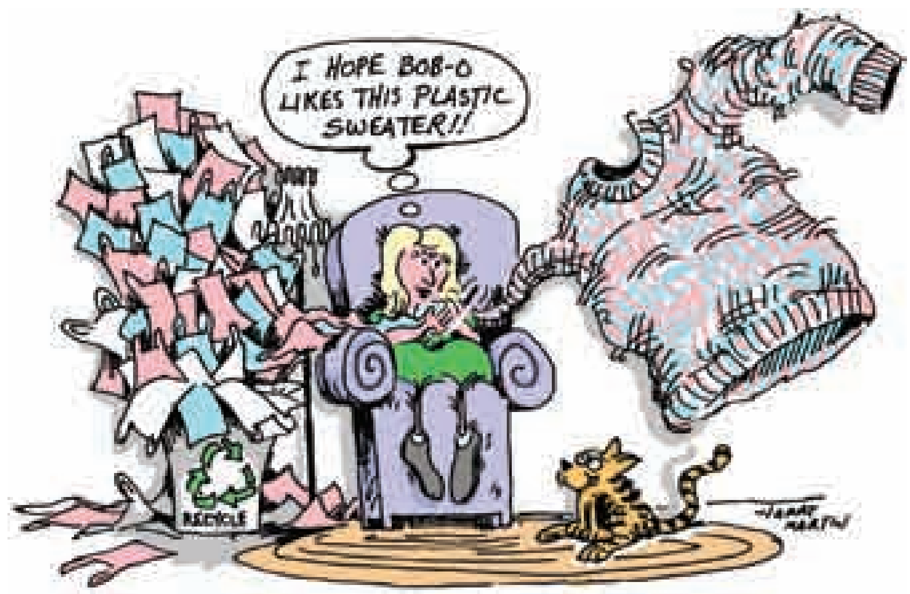
Crafty Recycling

by Kathleen Jarschke-Schultze



Ingenuity always gets my attention—I love clever. I've been enamored lately of crafts that reuse materials in different ways than they were originally intended. Reusing something is a step up from recycling because the only energy used to process these materials (except for a few tools) is your own.

Looming Large

Folks at Bring Recycling in Eugene, Oregon, showed me how to turn old T-shirts into something other than rags—rugs. I happen to have a continuous supply of worn-out, stained T-shirts, courtesy of my husband, Bob-O, who wears T-shirts to work installing renewable energy systems. He wears through them fairly often—although if I did not rescue the worn-out T-shirts from the laundry, he would still be wearing them.

To try this yourself, first you'll need to make a loom. I used 1-by-1s because I already had them, and cut two pieces 18 inches long and two pieces 30 inches long. I screwed them together to form a rectangular wood frame. Next, around the front of the frame, I hammered in one, four-penny nail every inch, leaving a 3-inch bare area in each corner. You may remember little plastic looms from your childhood—the humble beginnings of many potholders. This is just a larger version of those looms.

The T-shirts need to be clean, although they can be stained and have logos, words, or pictures on them. Bring's instructions advise cutting inch-wide rings of T-shirt starting from the bottom until you reach the neck. You end up with loops of T-shirt material. I modified this preparation (more about that later).

Stretch one T-shirt loop from nail to opposite nail vertically. Continue until all the nails across the top and bottom are sporting loops. Starting on the sides, attach another loop on a nail and weave it through the up-and-down loops to the corresponding nail on the other side. Continue until all nails have a loop on them and you have woven a rectangle of material.

To finish the edges, start in a corner and pull one loop off its nail. Pull the next loop off its nail and slip it through the previous loop. Repeat, continuing around the piece until you are at the end of the loops. By this time your piece is off the loom completely. Tie off the last loop or sew it to the piece.

I have used these little rugs for seat covers, car floor mats, and place mats. You could even hook the individual rugs together to make one big rug.

Cutting a Rug

I made more frames and took them to my family reunion, along with an abundance of T-shirts. Somehow, my sister-in-law Melva and I got stuck cutting all the shirts into loops. Boy, were our hands getting sore running those scissors. Then Melva accidentally tore a shirt. Material was coming off in one long, inch-wide strip. She kept tearing and ended with a

pile of very workable cloth. We found that if you start tearing a T-shirt, you can get one long strip about 30 feet long. But without the loops, that called for a different weaving strategy.

Starting at the top of the loom, we tied off one end of the cloth to the first nail on one side and looped the cloth back and forth around the nails, side to side until we reached the last nail on the side. There was now one continuous run of material strung back and forth on the side nails. Turn the loom 180 degrees. This puts your ball of material at the top. Bring the material strip around the now top corner nail. Since your loom is now strung top to bottom, start weaving the material through side to side: over one, under one, and repeating until you get to the other side. Loop around the nail and start back—over one, under one—until you have filled all the nails.

After we discovered this method, we never went back to cutting loops. Using strips instead of loops makes for a finer, thinner, more pliable, and, I think, more attractive end product. This is a very easy craft for all ages. My 91-year-old dad even made himself a little rug for camping.

Are there plastic crocheted backpacks looming in your future?

Fantastic Plastic

I got lost on the Internet awhile back and happened upon a video that shows how to reincarnate plastic shopping bags. In the video, Bre Pettis of *Make* magazine and his friend Anda from Etsy (an online marketplace for handmade goods) show how to make a messenger bag out of plastic shopping bags—you know, the bags you wind up with because you won't relinquish your cotton shopping bags to your husband, since he doesn't take care of them like you do. (Remember the T-shirts?) I put my own spin on their idea.

First, cut the handles and the bottom seam from your plastic bag. Fold it twice until you have eight layers. If there is printing on the bag, you need to turn the bag inside-out. Place it between two sheets of wax paper. Iron it at a setting roughly above polyester, but below rayon. You'll have to adjust for temperature differences of your iron.

You end up with a piece of Tyvek-like material, stronger and thicker than the original bag. This can be sewn into different projects like reusable shopping bags or messenger bags. To sew it, just overlap the pieces and use a zigzag stitch.

I sent the link to my niece, Elisa, and she dug under the sink, got some plastic bags, and turned out the cutest little shoulder bag. She's thirteen and well on her way to fabricating a creative life.

Plastic Redux

I followed another Web thread and found another use for plastic bags—crocheting them. I know how to crochet and I'm not going to try to explain that here. There are books or people you know who can do that better than me. But I will tell you how to process the bags for use.

Take the plastic bag and fold it upon itself, leaving the handles and bottom seam at either end. Cut off the handles and the bottom seam. Still keeping it rolled up, cut it into half-inch sections like you would noodle dough. Take a cut loop and loop it through itself and around another loop. Then take another loop and loop it through itself around the last loop, creating a chain of loops. By continuing this, you will end up with a long, double strand of plastic.

I found that it was easiest to use a large plastic crochet hook, such as an N-15 (10 mm). The plastic can be rolled into a ball like yarn, but it does not act exactly like yarn. It's all about the tension you keep on the plastic strands as you crochet them. I separated my plastic yarn into colors. This made it easier to add decorative patterns to my project.

I made a rather large drawstring backpack that I use sometimes as a daypack and usually as a bag to hold all my cotton shopping bags. It seems like a fitting end for all those bags. It's not really the end though. When my crocheted plastic daypack wears out, I can recycle it too.

These are easy, feel-good projects that do not require a lot of money. Most of the materials are free and the tools you buy or make are reusable. Something about that makes these crafts more enjoyable. I guess you could say I just have good trashion sense.

Access

Kathleen Jarschke-Schultze (kathleen.jarschke-schultze@homepower.com) is in full harvest mode at her off-grid home in northernmost California.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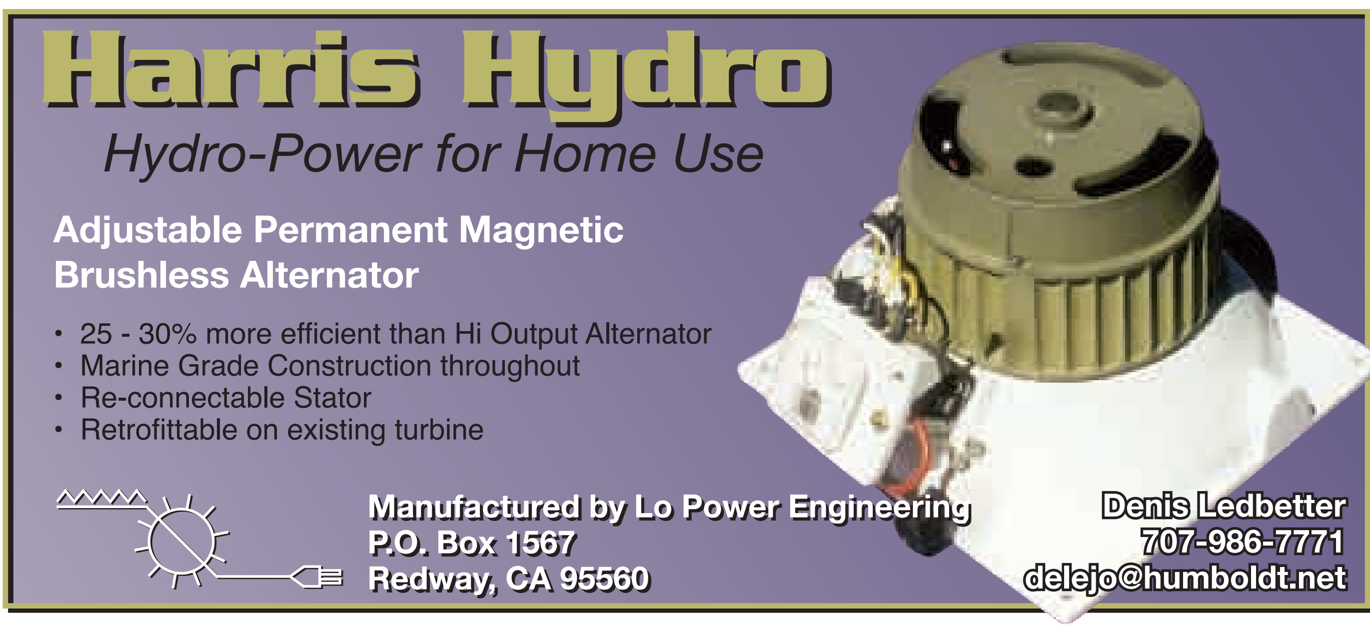
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Oct. 29, '08. Davis, CA. Small Wind Workshop. On issues & hurdles facing small wind energy in CA; will gather info to develop a report on issues & solutions. Info: CA Wind Energy • Collaborative sjjohnson@ucdavis.edu • http://cwec.ucdavis.edu

Arcata, CA. Workshops & presentations on RE & sustainable living. Info: Campus Center for Appropriate Technology • 707-826-3551 • ccat@humboldt.edu • www.humboldt.edu/~ccat

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FLORIDA

Melbourne, FL. Green Campus Group meets monthly to discuss sustainable living, recycling & RE. Info: fleslie@fit.edu • http://my.fit.edu/~fleslie/GreenCampus/greencampus.htm

IOWA

Iowa City, IA. Iowa RE Assoc. meetings. Info: 319-341-4372 • irenew@irenew.org • www.irenew.org

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Hudson, MA. Workshops: Intro to PV; Advanced PV; RE Basics; Solar Hot Water & more. Info: The Alternative Energy Store • 877-878-4060 • support@altenergystore.com • http://workshops.altenergystore.com

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West Branch, MI. Intro to Solar, Wind & Hydro. 1st Fri. each month. System design & layout for homes or cabins. Info: 989-685-3527 • gotter@m33access.com • www.loghavenbbb.com

MISSOURI

New Bloomfield, MO. Workshops, monthly energy fairs & other events. Info: Missouri Renewable Energy • 800-228-5284 • info@moreenergy.org • www.moreenergy.org

MONTANA

Whitehall, MT. Seminars, workshops & tours. Straw bale, cordwood, PV, more. Info: Sage Mt. Center • 406-494-9875 • www.sagemountain.org

NEW HAMPSHIRE

Rumney, NH. Green building workshops. Info: D Acres • 603-786-2366 • info@dacres.org • www.dacres.org

NEW MEXICO

Six NMSEA regional chapters meet monthly, with speakers. Info: NM Solar Energy Assoc. • 505-246-0400 • info@nmsea.org • www.nmsea.org

NORTH CAROLINA

Oct. 4–5, '08. Beech Mt., NC. Microhydro Workshop. Info: WNCREI • 828-262-7333 • wind@appstate.edu • www.wind.appstate.edu

Saxapahaw, NC. Solar-Powered Home workshop. Info: Solar Village Inst. • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

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Cottage Grove, OR. Adv. Studies in Appropriate Tech., 10-week internships. Info: Aprovecho Research Center • 541-942-8198 • apro@efn.org • www.aprovecho.net

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Philadelphia Solar Energy Assoc. meetings. Info: 610-667-0412 • rose-bryant@verizon.net • www.phillysolar.org

TENNESSEE

Summertown, TN. Workshops on PV, alternative fuels, green building & more. Info: The Farm • 931-964-4474 • ecovillage@thefarm.org • www.thefarm.org

TEXAS

El Paso Solar Energy Assoc. Meets 1st Thurs. each month. Info: EPSEA • 915-772-7657 • epsea@txses.org • www.epsea.org

Houston RE Group, quarterly meetings. HREG • hreg@txses.org • www.txses.org/hreg

WASHINGTON STATE

Guemes Island, WA. SEI '08–'09 workshops. Oct. 4, '08: Intro to RE; Oct. 13–16, '08: Solar Hot Water; Oct. 20–24, '08: Hydro Electricity; Apr. 6–11, '09: Wind-Electric Systems Maintenance & Repair; Apr. 13–18, '09: Homebuilt Wind Generators. Info: See SEI in Colorado listing. Local coordinator: Ian Woofenden • 360-293-5863 • ian.woofenden@homepower.com

WISCONSIN

Custer, WI. MREA '08–'09 workshops: Basic, Int. & Adv. RE; PV Site Auditor Certification Test; Veg. Oil & Biodiesel; Solar Water & Space Heating; Masonry Heaters; Wind Site Assessor Training & more. Info: 715-592-6595 • info@the-mrea.org • www.the-mrea.org

Amherst, WI. Artha '08–'09 workshops: Intro to Solar Water & Space Heating Systems, Installing a Solar Water Heating System, Living Sustainably & more. Info: 715-824-3463 • chamomile@arthaonline.com • www.arthaonline.com

INTERNATIONAL

CHINA

Oct. 10–12, '08. Qingdao. Intl. Building Energy Saving & RE Utilization Fair. Info: www.qdcese.com

COSTA RICA

Jan. 1–9, '09. Mastatal. Solar Electricity for the Developing World. Hands-on workshop. Info: See SEI in Colorado listing. Local coordinator: Ian Woofenden • 360-293-5863 • ian.woofenden@homepower.com

Jan. 31–Feb. 9, '08. Durika. RE for the Developing World. Hands-on workshop. Info: See SEI in Colorado listing. Local coordinator: Ian Woofenden • 360-293-5863 • ian.woofenden@homepower.com

GERMANY

Oct. 9–12, '08. Augsburg. RENEXPO. Exhibits & congress; solar technology, green building & more. Info: www.energy-server.com

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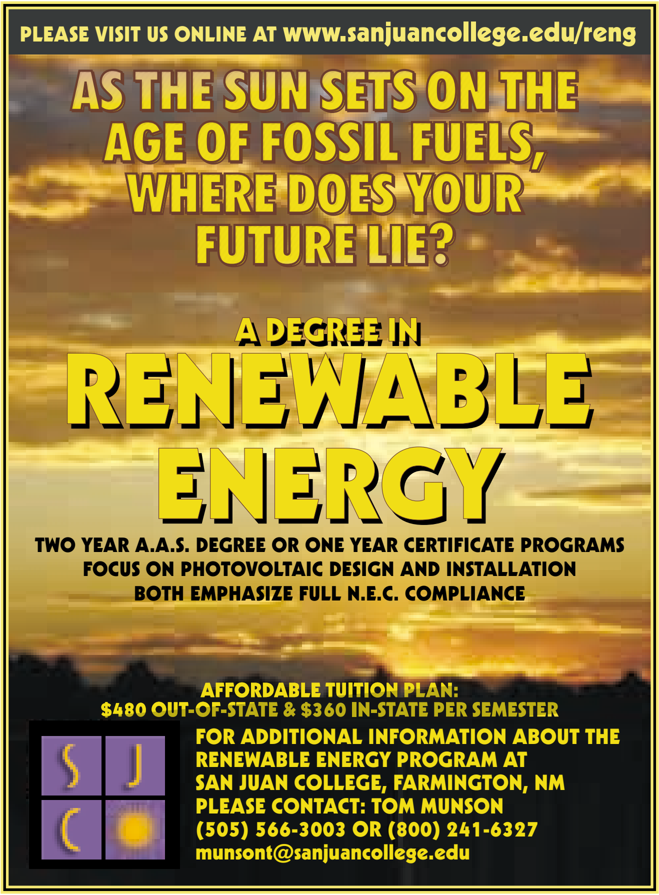
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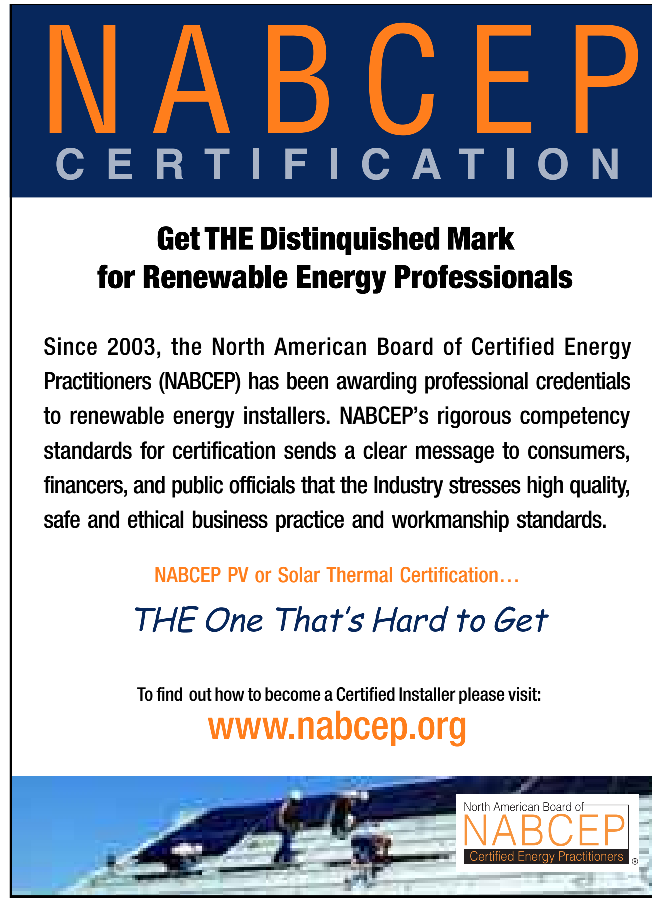
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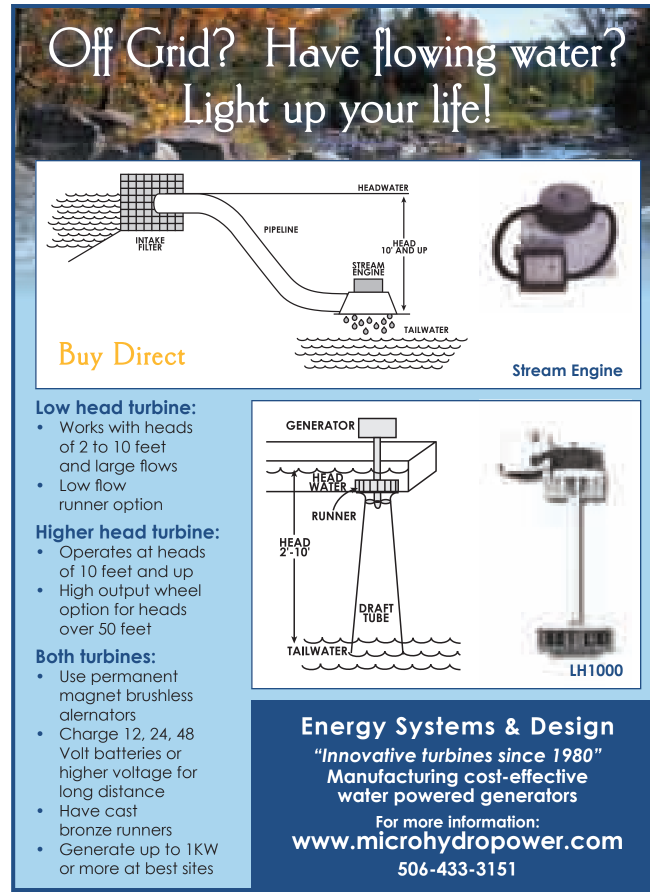
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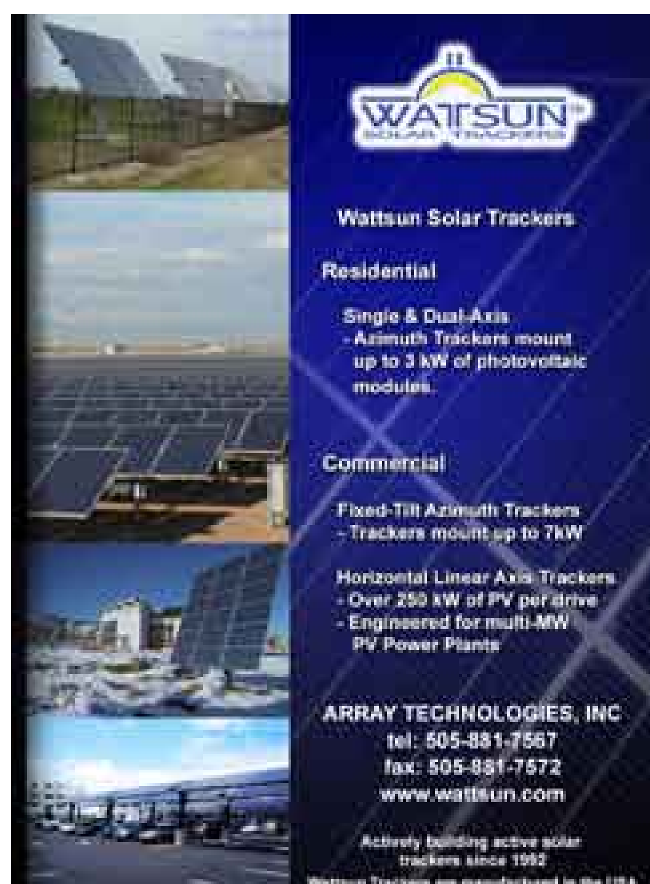
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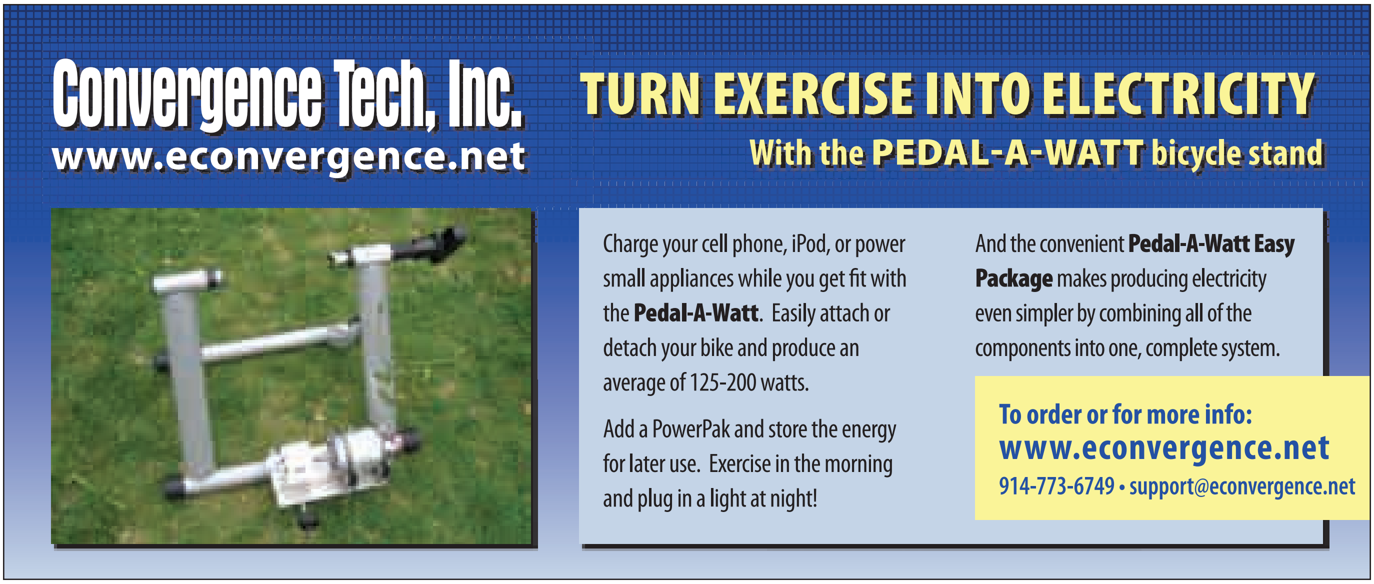
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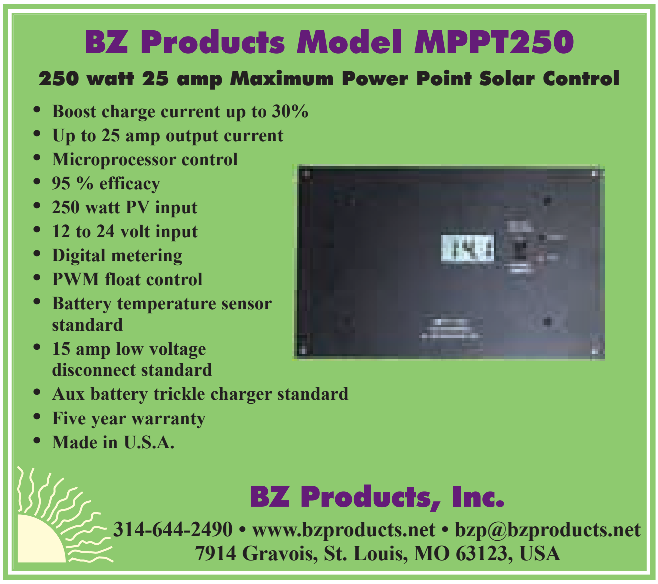
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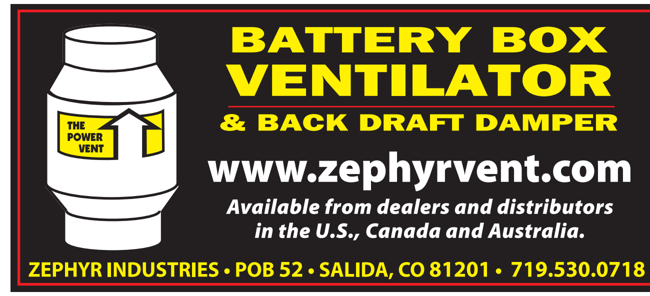
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RE People

Who: Derik Veenhuis & Dorly Muller
Where: Redway, California
When: 1982 to present
Why: Why not?

Derik Veenhuis and Dorly Muller built their off-grid lifestyle in stages.

Looking at the 8-kilowatt system now in place at Derik Veenhuis and Dorly Muller's off-grid homestead, it's hard to imagine the 32-watt PV module that started their RE journey a quarter of a century ago. Today, their ever-evolving installation serves as a march through history—from Derik's initial tinkering to his present-day business designing microhydro turbines.

You started out in a trailer?

I stumbled upon Humboldt County in the 1970s…and was taken by the back-to-the-land culture. I ended up buying six acres with friends in 1982. Four of us crammed into a little trailer with 12-volt lights, a single Arco module, and one little battery…We had one panel, and we thought we were in heaven. Who could ever want more, right? But come winter, things got pretty tight.

Were you the electricity geek of the bunch?

Yeah, pretty much. I went to a university and took physics, but I never graduated from there. But I could fix cars. Once you've got auto electrics down and 12-volt DC down, then the rest comes pretty easily.

How did you get started with microhydro?

We messed around with what we thought were water wheels—a fan blade and just about anything. It didn't really work, so we finally bought a plastic Pelton wheel—a copy of the Harris wheel—and put that on a little electrical box. Our water source was pretty high up—200 feet up—but we were able to get 5 amps on a 1-inch line. You couldn't use it all!

And when did the house come about?

We spent one winter in the trailer and that was enough. As soon as the weather broke, we sold the trailer, bought a couple of units of lumber, and built a 1,200-square-foot "box." We didn't have a clue—we measured everything in meters and made all of our cuts with a chain saw.

How has your solar-electric system grown?

Once we had the house, something had to change. Every year or so, we'd buy a couple more modules. We'd buy whatever was cheap—we weren't concerned with buying the same kind. Now, we have a collection of different modules on the roof and on the ground—half connected in parallel and the other half connected in series.

And the hydro system?

We started with homemade a brush generator hydro that produced 100 watts, and when the house was completed, we upgraded to a car-alternator type. That was the thing to do back then, but they required a lot of maintenance. That's when we began developing our own hydros.

What's the system like these days?

It's a hybrid with 4 KW of solar, 4 KW of microhydro, and no backup generator. We have more than enough power for the house and shop. The hard times are October and November, when it's cloudy and not raining yet.

Have you ever considered connecting to the grid?

We've thought about it, but because our house wasn't built to code to start with, [officials are] fussy about it. We'd have to essentially rebuild our house…Initially we were opposed to connecting to it because of nukes. Nowadays, if you can do it, then it seems that you should.

—By Kelly Davidson

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